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Type locality of ***Coronosporidium ecuadorianum*** gen. & sp. nov.
(Sosa & al.— FIG. 1, p. 112)

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Back cover (online edition only):
REPLACE single bottom line by
(Kaur & al.—Figs 2,3; p. 678)
Maninder Kaur, ARTIST

Back cover (printed hard copy only): after bottom line
ADD: Maninder Kaur, ARTIST

Reviewers — volume one hundred thirty-four (1)

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2019 Mycotaxon submission procedure

Prospective Mycotaxon authors should download the Mycotaxon 2019 guide, review & submission forms, and Mycotaxon sample manuscript by clicking the 'file download page' link on our Instructions to Authors page before preparing their manuscript. This page briefly summarizes our '4-step' submission process.

1—Peer review: Authors first contact peer reviewers (two for journal papers; three for mycobiota/fungae) before sending them formatted text & illustration files and the appropriate 2019 Mycotaxon journal or weblist reviewer comment form. Experts return revisions & comments to both the *Editor-in-Chief* <editor@mycotaxon.com> and authors. All co-authors must correct and *proof-read* their files before submitting them to the *Nomenclature Editor*.

2—Nomenclatural review: Authors email all **error-free** text & illustration files to the *Nomenclature Editor* <PennycookS@LandcareResearch.co.nz>. Place **first author surname** + **genus** + 'Mycotaxon' on the subject line, and (required) attach a completed submission form. The Nomenclature Editor will (i) immediately assign the accession number and (ii) after a few weeks return his notes and suggested revisions to the author(s) and *Editor-in-Chief*.

3—Final submission: All coauthors thoroughly revise and proof-read files to prepare error-free text and images ready for immediate publication. Poorly formatted copy will be rejected or returned for revision. They email the final manuscript to the *Editor-in-Chief* <editor@mycotaxon.com>, adding the **accession number** to the message and **all** files, which include a **(i)** revised 2019 submission form, all **(ii)** text files and **(iii)** jpg images, and **(iv)** FN, IF, or MB identifier verifications for each new name or typification. The *Editor-in-Chief* acknowledges submissions within two weeks of final submission but requests authors to wait at least 14 days before sending a follow-up query (without attachments).

4—Final editorial review & publication: The *Editor-in-Chief* conducts a final grammatical and scientific review and returns her editorial revisions to all expert reviewers and coauthors for final author approval. Author-approved files are placed in the publication queue.

The PDF proof and bibliographic & nomenclatural index entries are sent to all coauthors for final inspection. After PDF processing, the *Editor-in-Chief* corrects only PDF editorial/conversion and index entry errors; corrections of all other errors are listed in the Errata of a subsequent issue for no charge. Authors will pay fees for mycobiota uploads, optional open access, and correction of major author errors to the *Business Manager* <subscriptions@mycotaxon.com> at this time.

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From the Editor-in-Chief

On time! (for a change)—Loyal Mycotaxon authors and readers are undoubtedly weary of the constant stream of editorial apologies following yet another issue released 1–2 months after the end of a March, June, September, or December quarter. We are equally tired of apologizing to you. Thus it is with immense pleasure that we announce the release of Mycotaxon 134(1) **in March!** To ensure future timely journal delivery, we [i] urge authors to send their manuscripts to the Editor-in-Chief immediately after receiving their final review from the Nomenclature Editor and [ii] set a June 15 closure deadline for 134(2), the 2019 April–June issue. Submissions received after that date will be scheduled for the following (July–September) issue.

Mycotaxon 134(1) presents 14 papers by 64 authors representing 10 countries and peer reviewed by 30 expert reviewers. The issue opens with Ronald H. Petersen's 110-page lively and welcome historical treatise on 19th century mycologists in North America. This provides us the opportunity to introduce two new journal divisions—History & nomenclature and Taxonomy—to supplant our former 'Research papers' designation. ["Biodiversity & ecology" still find their home under the Mycobiota/Fungae summaries of papers posted on the Mycotaxon website, here announcing a checklist of fleshy non-gilled fungi from Kerala uploaded in February.]

The 2019 January–March Mycotaxon also proposes two new genera (*Anisospadicoides* with two species from Peru and *Coronosporidium* from Ecuador) and seven species new to science representing *Anamylopsora, Lemonniera, Perenniporia,* and *Rosellinia* from China; *Coronosporidium* from Ecuador; and *Spadicoides* from Peru.

New species range extensions represent ascomycetes *Hymenoscyphus, Parascutellinia,* and *Scutellinia* for Turkey and *Trichoglossum* for India, ascolichens *Bilimbia, Pyrenula, Toninia* for mainland China, and the basidiolichen *Sulzbacheromyces* for Thailand.

Plant pathologists especially will welcome the paper covering *Penicillium* causing blue mold on bulbs, roots, and tubers that tabulates where to find references to descriptions, culture methodologies, phylogenies, and hosts for each species.

Warm regards,

Lorelei Norvell (*Editor-in-Chief*)
22 March 2019

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North American mycology comes of age: the 19th century participants and their roles

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Abstract—Mycology in North America in the early 19th century hung by a single thread. By century's end there were numerous workers in diverse mycological fields. The players, their lives, and their roles sketch the development and growth of the science to set mycology on a steady course by century's end.

Europe's head start

Although botany had a thread of presence in colonial and post-colonial North America, Europe's society developed somewhat earlier than American, with selected national capitals achieving cosmopolitan status before 1800. London, Paris, Madrid, Rome, Vienna—all vied for sophistication in the midst of poverty, disease, and superstition. But as the emergence of the binomial system of plant naming (Linnaeus 1753—Species Plantarum) took root post-mid-century, local plants were collected, herbaria initiated, and floras written and often illustrated (Petersen 2001). Even examples of fungi were being publicized: in England, the 1787–1813 Colored Figures of British fungi or mushrooms by James Sowerby (1757–1822), William Curtis's Botanical Magazine (first issued in 1787), and the 1788–1791 An History of Funguses about Halifax by James Bolton offered a sampling of local mushrooms. In Paris, the 1791–1812 Histoire des Champignons de France by Bulliard (1752–1793) offered hundreds of fungi—all illustrated—while the 1790 Traité des Champignons by Paulet (1740–1826) also contributed. In the future Germany, J.C. Schaeffer (1718–1790) published four volumes of

Fungorum qui in Bavaria... (Schaeffer 1762–1767), and Batsch (1761–1802) summarized fungi from farther north in his Elenchus Fungorum (Batsch 1783–1789). From Scandinavia came the 1790 Beata ruris by Holmskjold (1731–1793) and, of course, the Species Plantarum by Linnaeus (1707–1778). This productive era in European mycology has been best summarized by Ainsworth (1976).

The narrow strip of British colonies along the North American Atlantic coast saw some botanical explorers imported from England in the 17th century. During the 18th century, Catesby, the second Clayton, the Bartrams (father and son), Linnaeus's student Pehr Kalm, and others explored botanically, but their plunder made its way back to their homes in Europe (Petersen 2001). As the 18th century rolled into the 19th, new explorers arrived. André Michaux (1746–1802) and his son, John Fraser (1750–1811) and his son, John Lyon (1765–1814), Thomas Nuttall (1786–1859), and others prowled the forests, often into the wilderness west of the colonized coast. Their quest, however, was prompted not by pure botanical curiosity but rather by a desire to introduce American plants into European gardens. Whether from patriotic or financial motives, many thousands of plants were shipped to England and France accompanied by timber and furs from the more northern climes of Canada. The botanical exploitation of North America was gaining momentum (Petersen 2001).

During this formative period, the colonies fought a revolutionary war against British rule (1776–1779) and although emaciated, the colonies prevailed, resulting in independence. But the principle of independence did not make the colonies independent in anything but a political sense. The colonies owed a debt to France, Germany, and Poland for aid during the Revolution. Trade with Britain had included not only imports from the homeland but exports of American goods, both directions now strangled in the wake of war. Moreover, Tories (those in the colonies who supported British rule) remained in place. It would be another decade before the colonies would coalesce and adopt a constitution, with the colonies metamorphosing into states of a Union. Historically, the following century would see dizzying events, inventions, mercantile intercourse, immigration, urbanization—all punctuated by "The War between the States." From mycologists who could be counted on less than one hand, there grew a population of both fingers and toes. These roughly eight decades and the development of mycology on a "new" continent are the subject of this sketch.

In the first quarter of the 19th century, significant mycological compilations were offered, chief of which attempted to arrange the fungi into some

taxonomic system, sometimes patterned on quasi-religious schemes. In three ground-breaking treatises—the 1801 Synopsis Methodica Fungorum by Christiaan Hendrik Persoon (1761–1826), the 1816 Das System der Pilze und Schwämme by Nees von Esenbeck (1776–1856), and the first volume (1821) of Systema Mycologicum by Elias Magnus Fries (1794–1876)—each author praised his predecessor(s) yet reorganized the fungi to suit his personal philosophical framework. Fries's volumes especially became a primary source for mid-century mycologists (Petersen & Knudsen 2015), including most Americans.

The Atlantic Coastal Plain of North America drains the eastern Continental Divide Watershed. Just to its west, the Piedmont Plateau is elevated by some feet or yards. This slight discrepancy in altitude, it was found, could be used for waterpower as the rivers and streams dropped. Waterwheels were installed, manufacturing increased, and population centers grew apace. Once steam power was developed, the manufacturing hubs did not evaporate; only the means of power changed. As the 19th century wore on, one might have expected that mycology, an almost undiscovered corner of natural history, would have followed this string of population centers and major coastal port cities. This, as will be shown, would be a mistake.

In the newly minted United States, Lewis David de Schweinitz (1780–1834; Fig. 1) was born and raised in America (unlike his illustrious mycological forebears) as part of a Moravian colony in Pennsylvania. In 1798, his family rejoined the original colony in Germany, where Lewis obtained his divinity credentials. While there he botanized with his mentor Johannes Baptista Albertini, with whom he published a compilation of fungi in their region (Albertini & Schweinitz 1803). When Schweinitz returned to America, he remained involved with botany, including fungi. His first major mycological paper (Schweinitz 1822) summarized his observations of the fungi in North Carolina. His second offering (Schweinitz 1832), which covered the middle areas of eastern North America, was the first large mycological paper compiled, written, and published in the United States (Hewett & al. 2016, Arthur & Bisby 1918, Fries 1946, Johnson 1835, Rogers 1977) except for one earlier paper by Bosc (1811). Unfortunately, with Schweinitz's death in 1834, any possible first-hand American mentoring also died. American mycological research came to a pause except for a very weak dribble of specimens from America to Europe. As the only source of named vouchers for North American fungi, the Schweinitz fungus herbarium was to become the target of repeated visits and fragmentation (Petersen 1979).

Fig. 1. Lewis David de Schweinitz
[Mycological Notes no. 44, 1916]

When Schweinitz sailed to and from North America and Europe, his mode of transportation would have been a wooden, 2–3-masted ship, probably rigged for cargo (and ballast) with little room for passengers. His berth would have been spartan and strolls on deck invited seasickness. Such a ship was at the mercy of vicissitudes of winds and weather. Weather prediction was primitive, with "Red skies in morning, sailors take warning; red skies at night, sailors delight" bearing some truth.

Antebellum mycology

Whether it is called the "American Civil War" or the "The War Between the States," the events and the period were and remain indisputable. The causes were several and remain to this day blurred but filtered by time, so that a few sentiments still reverberate in American culture.

In the wake of the Revolution, with the northern states developing densely commercial manufacturing centers while the south continued its rural production of cotton, rice, indigo, etc., northern congressional representatives had legislated high tariffs to protect its industries, but such tariffs favored the north and punished the south. In the 1830s South Carolina voted to declare the tariff bill null and void ("sovereign nullification"), and this forced a legal discussion on "states' rights." Bound up with states' rights was the issue of slavery. Many in the north viewed slavery as inhumane and cruel, while in the south, slaves were property, just as were houses, horses, crops, and land—to be owned outright as chattel. After all, slaves were bought, sold, exchanged, and otherwise treated as property. The south saw its sovereign right to own slaves as being threatened, and as new states were admitted to the Union, there was a potential legislative imbalance of slave versus non-slave in the federal government. And if individuals had rights (to own slaves), then states had rights, one of which was to nullify federal laws in individual states, and if that failed, to secede. And thus the issue was joined. This era brought disruption to all society in the United States, and thence to other countries of the Americas and to Europe. "'Much good,' Henry W. Ravenel asserted, had blessed Blacks from enslavement. They had increased in number since coming to the United States, a sure sign of health and happiness, and were enabled here to be useful while daily making progress in attaining a higher level of civilization" (Haygood 1983: 228).

If a significant route to mycology as a discrete pursuit in the 19th century could be identified, it would proceed through a personal interest in "natural history," thence through botany. In botany there already existed individual American workers (rarely "professional") participating in collecting, identifying, and preserving green-plant specimens. For the two leading American mycologists of the first half of the century, this was their path of avocational migration. Both came to this activity in the 1840s, and (although one was a northerner) both were located in the southern states. Their backgrounds, however, were remarkably different.

Fig. 2. Moses Ashley Curtis
[Berkeley & Berkeley 1986]

Moses Ashley Curtis (1808–1872; Fig. 2) was already a frequent correspondent of Asa Gray (1810–1888; Fig. 3) and John Torrey (1796–1873). He was considered THE authority on southern mountain plants, which Torrey and Gray coveted for their work toward a North American Flora (Petersen 1980a). Curtis, a Massachusetts product, first moved to Wilmington, North Carolina, on the Coastal Plain, employed as a tutor, but after obtaining a Doctor of Divinity he became an Episcopal minister as a life's work. He had collected flowering plants around Wilmington and published lists (Curtis 1835, 1843), but diminishing returns of new taxa turned his mind to other plants. He

Fig. 3. Asa Gray
[Neilans, 1963]

corresponded with and sent specimens to Edward Tuckerman (1817–1886), the Harvard lichenologist, but soon became intrigued with fungi. Curtis came to the fungi following laudatory words from Torrey and Gray and through them, from William Jackson Hooker (1785–1865), the venerable Kew botanist. Curtis recognized his fledgling status, but over time he assumed the perceived role of overseer. But on beginning to take this new interest seriously and having nowhere to turn for help in recognizing and classifying various fungi, Curtis wrote to his old botanical friend, Asa Gray. Gray recognized the dearth of mycologically inclined Americans and advised Curtis to contact Miles Joseph Berkeley (1803–1889; Fig. 4) in England, who was already sharing his Anglican clerical duties with his mycological avocation.

Fig. 4. Miles Joseph Berkeley
[Grevillea, vol. 1. Frontispiece]

Curtis wrote a beseeching letter in 1846 (Petersen 1980a) and, considering the times, Berkeley "quickly" replied with encouraging words and willingness to receive and identify specimens from Curtis. (The arrangement, prevalent at that time, was for the supplicant to send specimens for identification while retaining a duplicate to which the name could be applied. The modus operandi has changed little to the present.) Thus began a 24-year relationship bracketing the Civil War, between the two clergymen cum mycologists: one master, the other acolyte. The post-Schweinitz mycological hiatus was closing.

For Curtis, one irksome item was the proposal of names for American plants by European workers, caused by specimens exchanged or exported from North America to foreign collaborators. Nevertheless, over his years with the fungi, Curtis would send a couple thousand specimens to Berkeley, who compassionately tacked Curtis's name on them (e.g., *Boletus spraguei* Berk. & M.A. Curtis).

Very soon thereafter (14 Apr 1847) Curtis wrote to Berkeley: "On the Santee, still further south, I have a mycological associate who is collecting pretty diligently, & the only person in the country, besides myself, who collects Fungi but I hope for assistance from Alabama also" [presumably from Peters in Moulton, AL].

Once involved with fungi, the only American predecessor of any note immediately reappeared in Curtis's interest. The pioneer work of collecting, classifying arranging higher plants in eastern North America had already brought Schweinitz into Curtis's orbit, but his early contribution on fungi covered a region in German city-states during the beginning of the 19th century (Albertini & Schweinitz 1803, Hewett & al. 2017). However, upon returning to the United States, Schweinitz studied the fungi he found on his routes between North Carolina and eastern Pennsylvania where he ministered over his Moravian congregations. Moreover, Schweinitz not only published on fungi but amassed a sizable herbarium that was preserved at the Academy of Science in Philadelphia some 21 years after his death.

In 1848, Curtis set his sights on examining the Schweinitz specimens. The curator of the Philadelphia herbarium, Elias Durand (born Élie Magliore Durand, 1794–1873) initially refused Curtis's request. Undaunted, during 1850 Curtis took advantage of a trip to the northeast to "drop in" on the herbarium; upon receiving permission to inspect the specimens and to take a fragment when enough material existed, proceeded to take large enough pieces to share with Berkeley (as well as a few other parties).

Henry William Ravenel (1814–1887; Fig. 5) represented the latest generation of southern family plantation owners. His home territory was the Coastal Plain of South Carolina, his crop chiefly Sea Island cotton and rice, and his work force slaves; his father and grandfather had been plantation and slave owners before him. After the usual academy education, Ravenel entered South Carolina College in 1829 at the age of 15 (the minimum age for enrollment). The student body numbered about 100 and the faculty six (Haygood 1983: 44). The curriculum included a bit more science than usual, but Ravenel,

Fig. 5. Henry William Ravenel
[Neilans, 1963]

graduating in 1832, would have had a grounding in the classics. Although at this time there was a concerted effort to enlarge the natural history library, the collection was no rival to those of older (northern) institutions, and natural history was not to be generally represented for another 20–30 years. (Asa Gray would not come to Harvard as a botanist until 1842 nor would laboratory-based teaching be offered for another decade or more.) Whatever respect and love of natural things Ravenel would gain had to come from within.

It should be noted that during Ravenel's college days (1829–1832), one campus society debated whether South Carolina should secede from the Union. Although decided in the negative, the topic presaged actual secession by over 30 years (Haygood 1983: 55).

Sometime near his graduation, Ravenel was persuaded to begin studies for a medical degree, but his father countered by offering his son a plantation of his own, where slave labor would relieve Henry of the rigors of a rural medical practice. In 1835 (age 21) Henry became engaged to Elizabeth Gallard Snowdon, daughter of another wealthy planter. Her father's wedding gift included "18 Negro slaves" and several shares of bank stock. From Henry's father came Northampton Plantation, 804 acres in the neighborhood of present-day Lake Moultrie, SC. "By the end of 1839 Ravenel, at the age of twenty-five, had a wife and family, land, slaves, the equipment and knowledge necessary to raise cotton, a winter house at the plantation, and a summer home in Pinopolis" (Haygood 1883: 76). A year later Ravenel bought an additional eight parcels for $6800: money seemed of little concern, and Ravenel bought a small microscope and books whenever he pleased.

In September 1846, Ravenel wrote to Curtis, thereby contacting another southern green-plant botanist even as Curtis himself was writing Gray, "can I get the like help [as Tuckerman in lichens] on the fungi? Can you introduce me to any botanist, American or foreign, who understands these things & will exchange with me, or will name my specimens for the gift of them?" (Haygood 1983: 102). It was not long before Ravenel, too, began to migrate toward mycology, although never giving up other botanical pursuits.

Dr. Ezra Michener's (1794–1887) voluminous correspondence, which contained letters from some of the most eminent botanists of his time, including Curtis, Ravenel, Tuckerman and Gray (Harshberger 1893, 1899), appears to have been destroyed (Shear & Stevens 1917) or held in private family hands (Harshberger 1899: 178–180).

Ezra Michener was born Nov. 24, 1794, on a fourth-generation farm in the small Quaker town of London Grove Township, Chester Co., Pennsylvania. His early education was in the local schools, and he showed signs of a passion for botany early in life. Facing the dearth of botanical literature for American beginners during his first two decades (Harshberger 1899), Michener overcame that hardship by teaching himself through trial–and–error (Kelly & Burrage 1920).

At age 21, Michener moved to Philadelphia in 1815 to live with the Dr. David Jones Davis family. During 1816, after attending botany lectures by Dr. William P.C. Barton, Ezra was appointed house surgeon at the Philadelphia Dispensatory (!)—salary $250 per year (Harshberger 1899), and in 1819, he married Sarah Spooner. By this time, Barton's Flora Philadelphicae was finally published with Florula Cestrica (1826) by William Darlington (1782–1863) not far behind. At last there was help of a sort, although neither book dealt in depth with the lichens and hardly at all with fungi.

At first, Michener was interested in higher plants and became involved with Darlington's Florula. It was probably this interest that led him to Curtis and later to Ravenel, both of whom had similar avocations. Later, perhaps in the early 1850s, Michener realized that one plant group missing from the list was the fungi, a group for which there was also little help in identifications. By the time Michener wrote to Curtis concerning fungi around 1852, he was a mature 56-year-old Quaker country physician in Chester County and a "prominent citizen interested in reform movements" (Shear & Stevens 1917). Almost all of his life had been (and would be) spent in a small village "almost entirely isolated," as he wrote, "from the seats of learning, from scientific libraries, and from personal intercourse with the cultivators of science" (Michener's autobiographical notes, as quoted by Shear & Stevens 1917). Michener's interest in fungi finally fell on welcoming eyes, and Curtis invited him to send as many specimens as he wished. They would be filtered and added to those bound for Berkeley in England.

The wanderers

Another actor entered the scene in 1847. Augustus Fendler (1813–1883; Fig. 6), a Prussian émigré, had been chosen by George Engelmann (St. Louis, Missouri) and Asa Gray to collect plant specimens in the far reaches of the southwestern territories (western Texas, New Mexico). After Fendler returned from the expedition to deliver his plunder, an extremely impressed Gray and Engelmann tried to send Fendler back again.

Although of humble origin and delicate health, Augustus Fendler emigrated from Berlin, Germany, to the United States in 1835 (age 22), with almost no personal belongings. His first job in Philadelphia was in a tannery, after which he worked at a lamp manufacturing business in New York. [Incandescent bulbs were not available for some years: lighting was by gas.] He moved on to St. Louis, where he arrived after a thirty-day trip on a paddle-wheeler up the Mississippi against the current. Although employed, he soon left for New

Fig. 6. Augustus Fendler
[Ann. Missouri Bot. Gard. 76(1). 1989]

Orleans, crossing the Mississippi, and walking through Illinois, Kentucky, and West Tennessee. Once in New Orleans he decided to continue to Texas, where he arrived in 1839, only two years after Charles Wright (more below), and stayed for about a year before returning to Illinois where he taught school for some time. The fall of 1841 found him on an uninhabited island in the Missouri River, where he lived in solitude (Canby 1885).

In 1844 he sailed back to Berlin, where he learned that sets of plant collections (exsiccati) could be valuable, and on his return to St. Louis he

started collecting plant specimens in various expeditions in the United States, including west Texas and eastern New Mexico. Panama was another destination. Fendler became known for the quantity and quality of his collections. Asked by Engelmann and Gray to return to Texas/New Mexico (Crosby 1973), Fendler flatly refused (Stieber & Lange 1986), but later emigrated to Venezuela, where he collected fungi and other botanicals (Caomhánach 2012).

Fig. 7. Charles Wright
[Wikipedia]

While many mycologists (and others) enjoy the outdoors and are eager to explore rarely investigated ecosystems—or well-explored places not

previously sampled for a particular fungal group—there is a special breed intent on gathering specimens merely for identification and to add to knowledge of taxonomic variation. Augustus Fendler was one of these and John Macoun would be another, but Charles Wright (1811–1885; Fig. 7) saw more of the world than the other two and brought home a greater spectrum of "plants." Of the three, he was home-grown, born 29 Oct 1811 in Wethersfield, Connecticut, on the family homestead where he died.

Early educated in local schools and Yale College (1831–1835), Wright was attracted to botany, although no particular mentor has been identified. As another northerner, M.A. Curtis, had moved south, upon graduation Charles also moved south to Natchez, Mississippi, where he was a family tutor on a plantation. A general financial depression of 1836 affected his employer and Wright was out of a job.

A rush of immigration was underway to Texas (then an independent republic) and Wright joined the migrants in 1837, walking from the Mississippi to the Sabine River. Wright became part of a surveying crew for a couple years, but he was always seeking and collecting plant specimens. In 1844, he established a correspondence with Asa Gray and sent a large gathering from Texas. Gray was impressed by the quality of the cache and gladly received Wright's harvest through upcoming years. He (Gray) acted to portion out specimens according to the expertise of the recipient.

A seemingly unrelated event of no little consequence occurred in the 1840s and illustrates the times in which American mycologists were working. William Miller (1782–1849) gained gravitas by making Bible-based calculations precisely predicting the end of time. In 1844, many adherents gathered, but the appointed time came and went—the effect was "The Great Disappointment" that spawned sects known as Millerites, including Advent Christians (1860) and the Seventh-day Adventists (1863), the latter remaining with significant parishioners.

A small but diligent network of botanical correspondents operated in the northeast during the 1840s, but the group was quite willing to co-opt southerners who could contribute specimens from other regions and simultaneously reveal new taxa. Gray, Tuckerman, William Oakes (1799–1848), and Stephan Thayer Olney (1812–1878) were prominent in northern botany. A small botanical clique was developing in the south, but always in touch with the northern savants. The chief printed manual for the southerners

was that by Stephen Elliott (1821–1824), for the books by Eaton and Gray did not adequately treat the southern flora.

Once in touch and focused on mycology, Curtis advised Ravenel on preservation of fungus specimens (a universal problem). Detailed notes on pileus color, lamellar attachment, and spore color were needed before pressing, since all were distorted during the preservation process. To Gray, Curtis commended Ravenel's vigor and quantities of specimens. Despite the yawning discrepancy between Ravenel's wealth and Curtis's miserly salary and the manner of their upbringing, the two men did share a passion for botany and nature.

In March 1848, Ravenel visited Curtis in Society Hill, North Carolina. During their conversation, Ravenel inquired about establishing direct contact with Berkeley, as Curtis wished to remain the sole source (and filter) of American fungi to the Englishman. Eventually relenting, Curtis wrote to Berkeley to relate Ravenel's inquiry, but also suggested the French botanist, Camille Montagne (1784–1866). Berkeley countered, recommending his own new assistant, Christopher Broome (1812–1886). Berkeley seemed amenable to direct contact with Ravenel, but Curtis struck an agreement with Ravenel: all identified specimens could go directly to Berkeley, but unidentified specimens would go to Curtis for possible forwarding. Curtis stood firm in his coveted role as conduit. This difference of opinion marked a possible rift, but Ravenel demurred back into his role as collector. "If Ravenel was agreeable, he was not cowed" (Haygood 1983: 114).

Up north, Charles Horton Peck (1833–1917; Fig. 8) was born and raised in "Sand Lake, Rensselaer County, [which] was just a few clearings less than an unbroken forest." Peck's father and grandfather ran a sawmill manufacturing oak staves for sale in Albany, the nearby New York state capital. In his teenage years, Peck worked in the sawmill and attended "winter–school." "The school house that provided shelter for the master and a few children from the nearest homes was built of logs. The seats were made of saw–log slabs turned flat side up" (Haines 1978). Peck was described as having a "naturally delicate constitution."

In the late 1840s, Ravenel's confidence built, his library grew, and his circles of correspondence became substantial, perhaps especially including Tuckerman who was about to travel to Europe and who agreed to spread Ravenel's

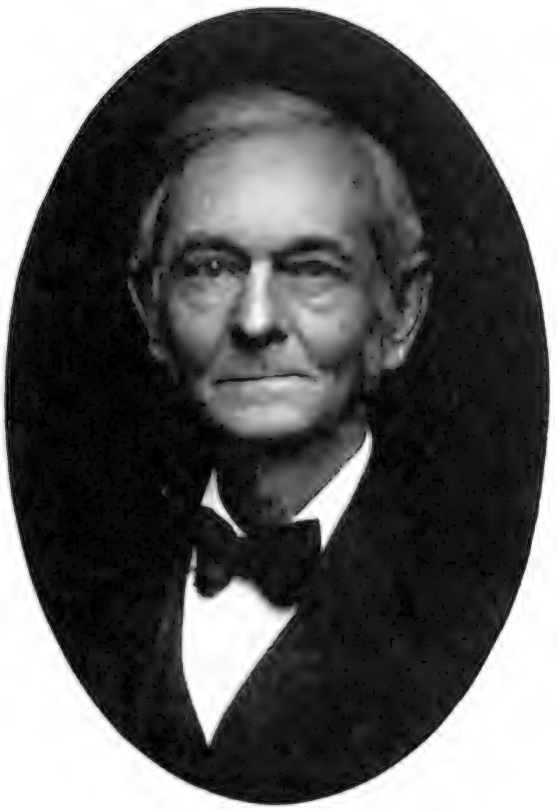

Fig. 8. Charles Horton Peck
[Bot. Gaz. 65(1). 1918]

name (and some specimens) to worthy European workers. Ravenel was delighted and particularly singled out Elias Fries as a possible recipient (and identifier) of his (Ravenel's) lichens. 1849 marked Ravenel's first botanical publication (on higher plants). By 1850, Ravenel was a respected member of the local agriculture society, state-wide botanist, and nation-wide botanical correspondent. Although Curtis was no longer essential, the two continued to exchange letters and occasional specimens, but Ravenel had already issued century 1 of Fungi Carolini Exsiccati without Curtis's help or credit. Curtis found little of substance to criticize but disparaged the many typographical errors in the labels. This needling and belittlement would continue for his entire life.

During 1845–1850, the European "potato famine" resulted in mass migration to the U.S., especially Irish. Unrest across continental European states also produced mass migrations of German, Swiss, and other German-speaking people. All groups were generally abjectly poor, illiterate and (especially the Irish) not Protestant but Roman Catholic. They met with discrimination including employment, integration into society, and even voter suppression. One result was ghetto enclaves, especially around disembarkation points, Boston (Irish) and New York (German). Ravenel considered the south's insularity a good thing, not a bad thing. Raw materials from the south (cotton, rice, sugar, tobacco) were essential to the north, so the north would not risk war and interruption of this flow.

But the "Irish Potato Famine" also provoked a different, if more esoteric, interest. In 1845, the popular English Gardener's Chronicle and Agricultural Gazette carried reports and editorials on the devastating "murrain" as it occurred in country after country. Two theories of its origin were published, that 1) the extreme weather variation of that growing season caused degeneration and rotting of plants, including tubers, which then, once weakened, were prone to molding or 2) the mold was the cause, not the result, of the disease. The former was a popular notion espoused by John Lindley, editor of The Gardeners' Chronicle; the latter was held almost solely by Rev. M.J. Berkeley, the clergyman who devoted much time with all sorts of molds, mildews, mushrooms, and toadstools (Large 1962; Berkeley 1845). Although no remedy could be put forward, the claim of disease caused by fungi was put forward decades before Pasteur's germ theory. Some time, however, would elapse before the media tangle would be resolved, but the paroxysm spawned an interest in possible links to other plant diseases caused by microorganisms, including fungi. Simultaneously, Grape Mildew spread across Europe, again with a fungus suspected as causal agent. Plant pathology was born and would become a dominant pathway toward mycology as an independent science.

One victim of the "potato murrain" was Sarah Macoun, who lived with her sons on the tiny family farm, now failing, in Magheralin, County Down, Ireland. With her last savings she and sons emigrated to Canada in 1850, settling in Seymour Township, Ontario, to resume farming.

When the Macoun family migrated, their conveyance might have been a ship rigged for both sail and steam propulsion. The former saved expense, using wind power and a rudder for control; the latter demanded fuel (coal)

and a complex, heavy engine. The means of propulsion would have been a paddle wheel, either posterior to the hull or as a side-wheeler, carefully designed so the paddle was not immersed too deeply.

One of her sons, John (born 17 April 1831) seemed not interested in farming, although "a small wiry man, with little formal education and without capital.... John by his own account seems to have been a pugnacious boy who always came out best in fights by using his left hand. He left school at thirteen and little is known about him until after he went, at the age of twenty, to Canada.... He made up his mind to become a teacher in order to have spare time for study of botany. After studying grammar on his own, he gave up his job, and walked the forty-three miles from the farm to see the county school inspector in Toronto, presumably with a view to seeking recognition for teaching. Three weeks later he gained his teacher's certificate" (McGeown undated).

Fig. 9. A.C.J. Corda
[Wikipedia]

In 1849, A.C.J. Corda (Fig. 9) came from the far-off Austro-Hungarian Empire to the German settlement of New Braunfels, Texas, at least to collect

plants (including fungi) and perhaps to make a home. Asa Gray and Curtis knew of his presence in America, although somewhat dismissively despite his impressive five-volume set of Icones (Corda 1837–1842) and compendious Anleitung (Corda 1842). Regardless of Corda's plans, on August 25, 1849, the ship carrying him and his specimens away from New Orleans disappeared and Corda was lost.

Enlarging the circle

In 1850, Ravenel was elected to membership in the Academy of Natural Sciences of Philadelphia and American Association for the Advancement of Science (AAAS), both societies considered prestigious in the U.S. The AAAS planned to hold its 3rd annual convention in Charleston (SC) in 1853, providing an opportunity for Ravenel to meet fellow botanists from all over the United States and to present research data to this audience. Also in 1850, the Episcopal diocese of South Carolina held its convention in Charleston; Curtis attended and Ravenel invited him to visit him at home. In their days together, they mixed with others of like persuasion—they agreed on the traditional idea of a single creation of man, rather than multiple human creations (including color).

Ravenel could also demonstrate his new French microscope. The cost was $35–40, some $5 more than Ravenel had budgeted. But while he was delighted at the result, neither he nor Berkeley could budge Curtis into purchase or use. Nonetheless, the instrument brought Ravenel another rung upward to parity with Curtis.

In 1848 Curtis published his first paper on North American mycology in Silliman's Journal (Curtis 1848). The journal's many typographical errors prompted Berkeley to publish their subsequent papers in the London Journal of Botany and (eventually) in the American Journal of Science and Arts (Shear & Stevens 1919). Three years later, Ravenel (1851) published on fungi (the last in a series of three papers—mosses, lichens, fungi) and issued the first century of Fungi Carolini Exsiccati in the following year (Ravenel 1852).

If Berkeley was irked by typographical errors of American type-setters, he was in good company. Young Elias Magnus Fries had confronted the same problem years prior when Hornemann, Fries's Danish mentor, offered to read galley proof of Fries's long Observationes Mycologicae (Fries 1815) but had difficulty reading Fries's handwriting (Petersen & Knudsen 2015). For Berkeley and Curtis, the introduction of the typewriter was still more than

40 years distant (late 1880s) and even then, only a single copy was produced, with errors creating problems, rectified only by inked-in notes. Complicating this process, type was set manually, letter by letter, diacritical mark by diacritical mark. Type-setting of scientific publications took unique skills, not everywhere available.

Charles Wright had made several forays in all directions within Texas and on to the Arizona Territory (1845–1852), when he finally started home, stopping in St. Louis to visit with George Engelmann. His time back home was short, though, for he signed up for the North Pacific Exploring Expedition under the leadership of Ringgold and Rogers. Casting off June 1853, the ships made their way from Norfolk, Virginia, through the Canary Islands and around the Cape of Good Hope, an area with great botanical richness. After a stop in Sydney, Australia, Wright sailed on to Hong Kong, the Bonin Islands, Japan, and the Bering Straits, arriving in San Francisco in October 1855. There, separated from the Expedition, Wright made his way home via Nicaragua.

Ante-bellum mycology

At 18, Peck entered the [New York] State Normal School in 1851 and took his first course in botany. He was determined to be a botanist. Upon graduation in 1852, he returned home to Sand Lake. "After graduation, he taught for a season in the district school and spent some months as a dry goods salesman in a general country store, but he quit because of poor health" (Haines 1978). During 1852–1853, Peck taught 60 students at Schram's Collegiate Institute at Sand Lake, and in 1855 entered Union College in Rensselaer Co. One teacher was Prof. Johnathon Pearson, known for his field trips. After graduating from Union College, Peck taught for three years at Sand Lake Collegiate Institute. Focusing his avocation on mosses, Peck established correspondence with Leo Lesquereux, Sullivant, and others. Soon, he started a friendship with Elliott C. Howe and Judge George W. Clinton (Atkinson 1918). He earned an M.A. from Union College in 1862 and started teaching at the State Street High School at Albany, thence to Albany Classical Institute, known more popularly as "Cass's."

Ravenel's health began to deteriorate in 1852: chronic dyspepsia and eye fatigue. To escape the summer heat, Ravenel spent the season in "the cool hills of North Carolina" (Haygood 1983: 154) ("The Smoky Mountains"). Returning in October, he resumed work on his 2nd century of the Fungi

Carolini Exsiccati, but poor health returned in a few months. By October 1852, he decided to move to Aiken, South Carolina, a newly "discovered" resort town with cooler, drier air becoming popular with Charlestonians. His Northampton estate was sold for $10,000. Part of Ravenel's move to Aiken involved selling and gifting numerous slaves: some staying with him and the family, some to his brothers and three families to his father. Arriving in Aiken in January 1853, he soon bought a farm and started building a house there. The cotton raised on Ravenel's new farm was termed Santee Cotton, of somewhat lower quality than Sea Island cotton from the coastal islands of South Carolina and Georgia. But significantly, there were peach orchards and vineyards on the farm and slaves to do the planting and picking. Parenthetically, improvement of crop rotation was used to bolster secession sentiments (a steady, profitable income was necessary for a prospective separate country—even in the 1850s).

Three months later, Curtis visited Ravenel in Aiken. Ravenel was planning a recreational trip to New York and Boston, and by July he was in Philadelphia. There he visited the Schweinitz herbarium, where he was invited to take duplicates, harvesting about 150. The second century of Fungi Carolini Exsiccati was issued in late 1853, and in the meantime, Ezra Michener had established a correspondence with Ravenel. Collecting assistance came from Thomas Milton Peters (1808–1888) of Moulton, Alabama, and John F. Beaumont (1825–?1865). By fall 1854, Ravenel was working on the third century of his exsiccati, but over Christmas his wife Elizabeth suffered a series of strokes and died in February 1855.

In 1854, a new correspondent, Job Bicknell Ellis (1829–1903; Fig. 10), saw a notice of Ravenel's Exsiccati in a bookstore and wrote him. Ellis sought help with his preoccupation, fungi, especially literature to help with identifications. In the ensuing correspondence, which extended to Ravenel's death many years thereafter, Ravenel recommended Greville's Cryptogamic Flora and Fries's Systema Mycologicum, Elenchus Fungorum, and "his new work," Epicrisis Systematis Mycologici.

Ellis was a native of Potsdam, New York, almost as far north in the US as possible and home to a horrendous climate—bitter cold and horizontal snow off the St. Lawrence River for many months each year. Ellis, of unsubstantial physique, apparently longed for a kinder climate (which remained a major theme for years).

At the tender age of 16, the bookish Ellis taught "winter school" in 1845, at Stockholm, St. Lawrence Co., (even farther north a short distance from

Fig. 10. Job Bicknell Ellis
[Bot. Gaz. 15(11). 1890]

Potsdam) "... for which service he received ten dollars a month [half in cash, half in grain, the last installment of which was paid twenty years later] and "boarded around" [rotating boarding with families of the students]. In 1849, "having completed his academical course," Ellis entered Union College but in his impecunious state also securing a teaching job in Charlton. By 1851, he graduated from Union College (age 22), moving to Germantown, Pennsylvania, in June. By September he moved to Albany Academy (New York) as classics teacher but with a growing interest in botany. After starting

his own private school (and failing), he taught at Bartlett's Boarding School in Poughkeepsie (1853). After three successive boat trips to New York City, each intended to last three days to "do the city," he always returned on the first train, suffering from a headache from the excitement of the city and the rigors of his trip.

In his 3rd century of Fungi Carolini Exsiccati (spring 1855), Ravenel included specimens from Charles Wright (1811–1885, specimens from Texas), Michener (Pennsylvania, apparently having short-circuited the Curtis connection), and Sartwell (New Jersey). Work began on the fourth century, with plans for a fifth. That summer, Ravenel contacted Camille Montagne in Paris, sending free sets of exsiccati. Montagne was effusive in thanks and praise and (of course) solicited more, sending a collection of his papers in repayment.

Over the winter of 1858, Augustus Fendler returned from his period in the mountains of Venezuela with plant specimens including fungi and offered the fungi to Curtis. Although not the sole plant collector in Venezuela over the 19th century (Patouillard & Gaillard 1888), Fendler spent four years (1854–1858) in the small town of Colonia Tovar, settled by immigrants from Baden in 1843. Colonia Tovar was (and is) enclosed by cloud forests of enormous biodiversity. Fendler collected avidly and his were among the first specimens from this area to be studied by North American experts.

Apprised of Fendler's fungus collections and confessing a shortage of money, M.A. Curtis wrote several letters soliciting support to purchase Fendler's Venezuelan fungi. To Charles James Sprague in Boston: (letter: 11 Feb. 1856) the following: "Do you, or your Society, or anybody (individual or corporate) feel disposed to take a share in a Mycological venture? Fendler is now collecting plants in Venezuela, and has got a few hundred Fungi, to which he will add more as opportunity offers. I can get possession of these, by promising a remittance immediately upon their receipt. I should be glad to have the elaboration of them, but am unable to make any offer, having no extra funds. If individuals or Societies would agree to take sets, I could better determine how to act in the premises. —Que dites vous?"

Curtis purchased the fungi for $100 before notifying Berkeley. After the fait accompli and under cover of apologetic intrusion, Curtis inquired whether Berkeley might be interested in Fendler's specimens. Berkeley acceded, and the collections were shipped. Fendler's sojourn in Venezuela was not

otherwise exciting to Northern Hemisphere mycologists, and his expedition was not even mentioned by Chardon and Toro (1934).

Fendler's Venezuelan collections included about 3000 phanerogams, ferns, and bryophytes and almost 400 specimens of fungi and lichens. Gray, Curtis, Tuckerman, and Sullivant (all familiar names) bought sets, and to pay for them, Gray and Curtis helped distribute specimens to subscribers (Todzia 1989).

During 1864–1871 Fendler returned to Missouri and settled in Allenton (Spaulding 1909). While there, he resumed plant collecting and became known to Henry Shaw, who hired him to work at the Missouri Botanical Garden. Fendler curated the first botanical specimens in the newly organized herbarium.

After Missouri and a few years in Europe, Fendler moved to Trinidad in the Caribbean, where his brother lived. He died there in 1883, surely one of the most intrepid collectors of his century, rivalled only by John Macoun and Charles Wright.

In 1855, Curtis requested Ezra Michener to collect and send a specimen of *Botrytis* (now *Phytophthora*) *infestans*, shown by Berkeley to be the cause of the "potato blight" of the previous decade. Michener attempted to do so but could not find a specimen. After some time, he wrote Curtis but, in addition to explaining the lack of a specimen, went to some lengths to tell Curtis why he was engaged in mycology. Michener wrote, "The inducements which led me into the study of the fungi are a desire to supply a blank in the catalogue of Natural productions of Chester County, which some of us contemplated—and while I could not obtain the means to determine all the species myself — I vainly hoped that my services as a collector of fungi might entitle me to the assistance which I stood in need of in determining species. —Disappointed in this hope, I have but little inducement to prosecute the study much farther—yet there is a charm attending it which will probably [con]tinue as long as I am able to pursue it." This was followed by: "How is the review of Schweinitz progressing? I have been watching for it in the Journal of the Academy."

As might be expected, Michener understood the importance of the Schweinitz herbarium—first in Phanerogams and later especially the fungi—and in the winter of 1855–1856 traveled to Philadelphia, not long after Curtis (followed by Ravenel) had raided the Schweinitz fungi. Knowing that Curtis had sent many Schweinitz splits to Berkeley, Michener (6 Nov 1855) wrote Curtis, "In a few days I expect to commence arranging Schweinitz Fungi—

and it would have been a great pleasure to have had the assistance of your corrections during the examination of his species. —I shall however implicitly follow his numbering and labeling [two words blurred] out in the Synopsis Fungorum" (Smith 1954).

Curtis must have been put off at what he thought was Michener's impatience for the Berkeley report on the Schweinitzians. Curtis's [lost] answer must have been peckish, for Michener answered penitently, unctuously using the "Thee" and Thy" of Quaker plain speech (Birch 1999). Michener took note of Curtis's words: "You need not trouble yourself by sending me specimens too often." Wounded, Michener went further. "It was a kno[w]lidge [sic] of thy numerous engagements in the Mycological field – apart from "business" proper, which has frequently led me to feel and to express a fear of trespassing too much upon thy time—and, so far as I can recollect, has prevented me from making any claim upon thy attention farther than it may have been convenient to thee to bestow—nor am I conscious of having manifested that "impatience" of which thee speak."

Perhaps to salve the tension produced by his words—or perhaps to rub some salt in the wound—Michener added, "In working over the first eight books of Schweinitz' Fungi, I have been grieved to find a number of the envelopes either missing or empty in addition to the many which [have been] rendered valueless by the ravages of insects.—Perhaps the destruction will not be so great after we get through the *Hymenomycetes.*" He was to find in the *Hymenomycetes* that many of the specimens had been reduced to a minimum, and he might have surmised that Curtis had taken enough both for himself and for Berkeley.

Married twice, and having attained 92 years of age, Ezra Michener died quite near home in Toughkenamon , Chester Co., Pennsylvania, on June 24, 1887.

J.B. Ellis's search for an ameliorated climate entered a new chapter, and in February 1855, the 26-year-old Ellis, accompanied by his sister, left Poughkeepsie, NY, for Charleston, SC, with the intention of teaching school there. Ellis called on one of the professors in the South Carolina College in Columbia, SC, to seek information on the subject. Said Ellis, "I told him that I had come South to teach and make a home there. He at once asked me whence I came, and when I answered from New York [State], he replied, while slowly swinging in his revolving office chair: 'Well, the state of feeling

between the North and South is such that I doubt very much whether you will succeed,'" (Haygood 1983). And he didn't. In March [1855] he and his sister made their way from Charleston to Alexander, near Augusta, Georgia, where he began teaching in an academy that fall. En route, he met with Ravenel, who hosted him graciously. The conditions in rural Georgia were odious—so much so that he returned to Potsdam (NY) after the first school term. Asked whether there was one incident he considered interesting during his sojourn in Alexander, Ellis opined, "No; the most interesting incident was to get away, that is very distinct, even now," (Anderson 1890). By 1856, he was Principal at Canton Academy, St. Lawrence Co., (a short distance SW of Potsdam). "... and on the eighth of April, 1856, an event took place which made it possible for him to do the enormous and valuable work he has since done for American mycology. This was his marriage to Miss Arvilla J. Bacon, who has been a faithful partner in all the vicissitudes of life, and a constant and painstaking assistant in his mycological work for the past thirty-four years," (Anderson 1890). In 1863, at the height of the Civil War, Ellis and his wife were teaching in the public schools of Potsdam village.

Even before the armed conflict of the Civil War, emotional involvement in the underlying issues was often strong, as shown by the discrimination J.B. Ellis confronted during his attempt to make a career in the south.

Another example of those who did not fit in was the Macbride family of Rogersville in East Tennessee, strict abolitionists in a state that was eventually to secede to join the Confederacy. Their lives were apparently subject to harassment, and they felt forced to move—not due north, but northwest, to Iowa. That state, although settled by pioneers from all directions including south, was predominantly sympathetic to the Union. With an agriculture-based economy, Iowa furnished foodstuffs as well as 75, 000 volunteers to the Union army. The Macbrides moved from town to town, finally settling in Princeton in Scott County. Certainly they did not dream that son Thomas would become a mycological leading light.

On August 12, 1856 Henry Ravenel (44 years old) married 25-year-old Mary Dawson. Ravenel's increasingly weak eyesight made microscope work distasteful (paralleling the later problems of Curtis). In 1857, Ravenel donated his higher plant herbarium to the Elliott Society of Charleston. As early as late 1859, Ravenel read Darwin's Origin of Species, vacillating on the question of immutability of species, but accepting certain points. In practical terms, in

Ravenel's mind his work on collecting and cultivating grape vines was more important than the philosophical premise of natural evolution.

Meantime, Curtis transferred to Hillsboro, NC, where a larger church afforded less time for botany, and he had thoughts of withdrawing from mycology altogether.

But Curtis could not divorce himself from floristic botany. Alvan Wentworth Chapman, M.D. (1809–1899), of Apalachicola, FL, approached Curtis to write a manual of the southern flora to match Gray's manual for the northeast. Many years later, Chapman wrote to Lamson-Scribner, "I believe the [Chapman] FLORA owes its existence to a suggestion of mine to Dr. Curtis about the year 1856 that we needed for the South a work something like what Gray had made for the North, and that he (Curtis) was just the man to do it. But at that time his hands were full of toadstools and he was rusty among the Phanerogams, and so turned over the matter to me, while promising every assistance in his power if I would undertake the job," (Lamson–Scribner 1893: 331). Chapman's first edition was published in 1860 (Chapman 1860).

During the war (1856, 1857, 1861, 1865) and after (1867), Charles Wright commuted back and forth to Cuba, each time returning with new collections of tropical plants and fungi. Gray parceled out the specimens, "As to the lower cryptogams, Mr. Wright's very rich collections were distributed in sets and published by specialists: the FUNGI by Berkeley and the late Dr. Curtis…," (Sargent 1889, Berkeley 1863, Berkeley & Curtis 1863). Except for short forays, Wright spent the rest of his days working with his own specimens in the Harvard Herbarium. As written by Gray: "By degrees [Wright's] strength was sapped by some organic disease of the heart, which had given him serious warning; and on the 11th of August [1885, in Wethersfield, Connecticut] he suddenly succumbed, while making his usual round at evening to look after the domestic animals of the homestead."

Gray summarized Wright's physical appearance: "Mr. Wright was a person of low stature and well-knit frame, hardy rather than strong, scrupulously temperate, a man of simple ways, always modest and unpretending, but direct and downright in expression, most amiable, trusty, and religious. He accomplished a great amount of useful and excellent work for botany in the pure and simple love of it; and his memory is held in honorable and grateful remembrance by his surviving associates" (Sargent 1889). Wright's collections formed the basis for scores of floras and monographs and offered the botanical

community glimpses of variation attainable in no other way than personal acquaintance.

The war years

Veterans of the American Revolution still alive into the 1860s were about to see a new, albeit internal, rebellion.

Ravenel slowly evolved from unionist to southern nationalist, while with the death of "the great compromiser" (Daniel Webster), polarization and simmering tensions tightened. The problem of slavery in the territories became critical. Ravenel believed sentiments were "unanimous" that South Carolina would secede if Lincoln were elected President, and by November he was ready to see South Carolina take the lead to secession. Tuckerman and Gray worried from afar; Ravenel hoped that their friendship could continue regardless of politics (Stevens 1919).

Early 1861 brought secession after the attack on Fort Sumter in Charleston harbor. Charleston was blockaded by the Union navy. "The blockade cut southern scientists off from contemporary European and northern contributions, and no one could concentrate properly on research when the fate of the entire country was being played out on the fields of Virginia." (Haygood 1983: 236). In fact, the northern mycologist J.B. Ellis was part of the blockading fleet. No transatlantic communication was allowed. Even postal service south to north was impossible, and the southern mycologists were marooned. Ravenel's health further deteriorated, including periodic deafness. Nonetheless, the fifth fascicle of the Fungi Carolini Exsiccati was completed and with it, "final withdrawal" from botany.

J.B. Ellis served in the navy during the Civil War. The latest innovation in ship building was the wooden hull covered with a layer of iron plates (i.e. "ironclad"), coupled with steam-powered propulsion, introduced in sea battle during the war.

Another fledgling mycologist would see less action. Albert Nelson Prentiss (1836–1896; Fig. 11), had been born on a farm near Cazenovia, New York, a location frequented later by Lucien Underwood. A product of local schools, in 1861 Prentiss graduated in a class of seven from the new Michigan State University. With war imminent, all seven enlisted in the army and were assigned to a camp. But in spite of secession and armed violence, the camp was closed, and group cashiered. The War was fought without them.

Fig. 11. Albert Nelson Prentiss
[Bot. Gaz. 21(3). 1896]

Unbeknownst to Ravenel or Curtis, another young man destined to influence American mycology had entered the population: Andrew Price Morgan (1836–1907; Fig. 12). "From this position [teaching in Dayton, Ohio, High School] he went into the Union army, first in the 84th Ohio Infantry—carrying a stoutly bound copy of [Asa] Gray's Manual in his knapsack—and again as First Lieutenant in the Fourth Independent Battalion O.V.C. Being a member of the Dayton Light Guards he was a well-drilled soldier and did a great deal of work drilling volunteers. At the close of his army service he was very ill with typhoid fever" (Kellerman 1907).

In 1862, a bill written by Vermont congressman Justin Smith Morrill (1810–1898) was made law. The "Morrill (or Land-Grant College) Act"

Fig. 12. Andrew Price Morgan
[Mycol. Notes (Lloyd) 31. 1908]

granted each state 30,000 acres per congressional seat (thus favoring the more populous northern states) for establishment of schools specializing in "agriculture and the mechanic arts." Some states used the land for its chief purpose, while others sold the land and turned the funds over to extant state or private colleges to create colleges of agriculture and engineering*. Military training was required in the curriculum, not least because the act came in the midst of the Civil War.

Yet another resident of Chester County, Pennsylvania, was Abraham Robinson McIlvaine (1804–1863), a prominent Quaker three-term congressman. In 1840, a son was born to the McIlvaine family: name, Charles (1840–1909; Fig. 13). Everything written about Charles points to a youth without financial restrictions, and the word "indolent" perhaps could be attached to him, at

* Numerous present–day colleges and universities still bear this notation (i.e. Texas A&M, Louisiana State University, Michigan State University, North Carolina A&T, etc.).

Fig. 13. Charles McIlvaine
[Harshberger. 1899]

least until he was seized by a life-centering crusade—the edibility of fleshy fungi. According to McIlvaine himself, the conversion event occurred in 1877 (age 37) as he rode through the forests of West Virginia.

Having been "educated" at the local county schools to the age of 11, Charles then attended Northwest Grammar School in Philadelphia for two years. This seems to have been the extent of his schooling. "He was not a university man and took no academic degrees, which was later to prove an embarrassment to the acceptance of his work in mycology" (Bowser 1972).

At his father's urging Charles raised a company of volunteers to support the Union cause, becoming attached to 97th Regiment of Pennsylvania Volunteers. For his efforts, he mustered as Captain. Later, he was offered promotion to

Major of the First South Carolina Cavalry (Colored), but demurred, citing ill-health. (While African-Americans were allowed to enroll in the Union military, their officers were strictly Caucasian.)

Called up twice to serve in the military in 1863 and 1864, Ravenel was excused from service due to poor health. Financially, at war's start Ravenel's principal income was from interest-producing investments (bonds of South Carolina banks). After secession, as these debts were converted into inflated Confederate dollars, Ravenel repeatedly put the income back into Confederate bonds; as it turned out, an unwise decision.

During the War, with foodstuffs becoming scarce, Ravenel extolled mushrooms as a food source. He and Curtis both enjoyed mushrooms pre-war, but now they became more exigent. Ravenel brought wild edible mushrooms to monthly meeting of the St. John's Agricultural Society; others brought fruits or vegetables.

The Curtis family was also in dire straits. Not only was the Union General Sherman's March to the Sea within a few miles of Hillsborough, but two sons were in the Confederate army. One, nicknamed "Non" came home for a brief leave, but upon returning to duty, was killed at the battle of Bentonville NC. Mary Curtis had become a gold star mother before the term was established, but her grief had to be contained as she ministered along with Moses to their congregation, also suffering their own calamities.

Charles Edwin Bessey (1845–1915; Fig. 14, next page), a farm-boy, was home-taught but received a certificate to teach. While he attended Seville Academy (Seville, OH), his father died in 1863 during the midst of the War, and Charles (age 18) began teaching in Wadsworth, Ohio. In 1866, Bessey entered Michigan Agricultural College, graduating in 1869. His advisor was Prof. Albert N. Prentiss, later Botany Department Head at Cornell University, and Bessey turned from engineering to botany. In 1869, Bessey became an instructor at Iowa State College of Agriculture in Ames, Iowa. Awaiting him there was a young student, Joseph Charles Arthur, eager to study botany and destined to play a major role in mycological research.

In 1864, Yankee infantry approached Charleston and St. John's Parish was abandoned by Confederate forces. Ravenel remained at his father's Pooshee plantation to help the family prepare for the Union army. All valuables were buried (some were stuffed in mattresses) and four months of provisions were

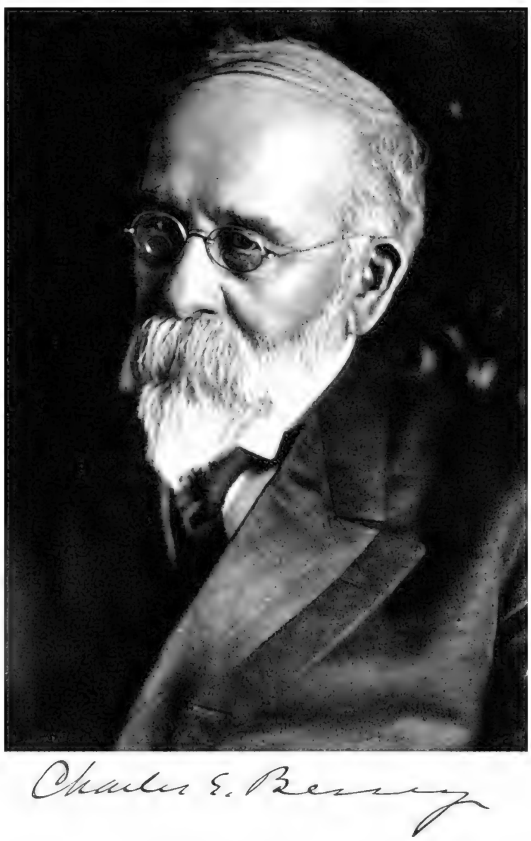

Fig. 14. Charles Edwin Bessey
[Amer. J. Bot. 2(10). 1915]

given to the slaves. On March 1, raiding parties reached Pooshee: "Horses, wagons, buggies, harness, the contents of the smoke house and root cellar, wine, guns, and poultry were all taken, but no one was hurt, no buildings were burned, and Ravenel was able to find comfort in the loyalty exhibited by the Pooshee slaves during the incursion." (Haygood 1983: 249). The home in Aiken was raided by renegade Confederate troops but largely left intact.

In spring 1865, the Confederate Army surrendered, and the War ended. General Sherman's march left a swath of destruction through Georgia and South Carolina. Confederate money was plentiful but useless. Hampton Hill (Ravenel's Aiken home) was intact and the orchards and vineyards untouched (Haygood 1983: 257–259). Other complications abounded, however: the

peach crop was bountiful, but with the obliteration of transportation, the crop could only be used locally. The situation extended to the crops of 1866 and 1867. By 1868, the crop could be shipped, but picking was desperate, and the crop arrived in New York bruised and low-priced. As early as 1865, Ravenel decided he should pay his newly freed slaves a salary, not "in-kind" housing, food, medical treatment, etc., but he had no money to pay them. So even though he and his family were safe, relatively healthy, and with a roof over their heads, life was not as comfortable as pre-War and useable money was tight. In the fall of 1865, Ravenel offered to sell important works from his library and gave his microscope to the family doctor in lieu of payment for the year, while spare fascicles of the exsiccati went up for sale.

Termination of hostilities

At War's end, American mycology remained in the hands of its two leading lights, Curtis and Ravenel. A third man, J.B. Ellis, was enthusiastic but otherwise occupied as a teacher. Born before or during the War, over the upcoming quarter-century, several others would emerge. A review of their circumstances indicates two major pathways to their careers: 1) almost all were born on family farms, anticipating family inheritance in their future; and 2) most made their way through a series of teaching jobs—public schools or academies—probably without a premonition of their eventual fate. Whether through a farm-boy's exposure to nature or an acquired interest in plants, interest likely progressed from nature to plants, thence to cryptogams or phytopathology and on to mycology.

It was in these years that electricity for lighting rapidly replaced gas, at least in the industrialized north.

Canada, of course, was little involved in the "War Between the States." In Ontario, John Macoun had been captivated by plants as a youth, collecting and identifying as many as possible without guidance. "Although almost entirely self-taught, his reputation as a botanist grew, and just ten years after leaving the farm, in 1869 he was offered the Chair of Natural History in Albert College, Belleville" (McGeown undated). By this time he was married (1 January 1862) with a family. Nonetheless 1872 found Macoun on a "botanical holiday" steaming across the Great Lakes. By chance, he met Sanford Fleming, chief engineer for the proposed Canadian Pacific Railway. Fleming offered Macoun a place on an upcoming expedition to lay out the route for the coast-to-coast route, which he gladly accepted (there is no record of his wife's

reaction). "Despite the privations of this journey, Macoun fell in love with the wilderness, and over the next ten years [1872–1881] made a number of long and strenuous journeys into the North-West Territories, the last two on behalf of the Canadian government. He published the observations made on these journeys in Manitoba and the Great North-West in 1882 (McGeown undated). In 1881, Macoun was appointed Botanist to the Geological and Natural History Survey of Canada and moved to Ottawa in 1882. "He became a charter member of the Royal Society of Canada and wrote a Catalogue of Canadian Plants and later a Catalogue of Canadian Birds. In 1886, Macoun was sent to England as a Canadian representative to the Colonial Exhibition. "He suffered a stroke in 1912, but fortunately recovered and later that year moved to Vancouver [British Columbia] .... He was engaged in writing his autobiography when he died of heart failure at Sidney, Vancouver Island, 18 July 1920" (McGeown undated).

John Macoun must take his place as the dean of collectors. His journeys preceded those of Augustus Fendler, Charles Wright, and others by some years, as an individual seemingly not fit to settle down for prolonged quiet but instead given to exploring hitherto unexplored and often uncivilized wilderness.

The War was over, and A.P. Morgan returned to teaching in Dayton, Ohio, but over the ensuing years, he suffered from "confinement in the school room" (Kellerman 1907). This seeming claustrophobia (who is to say that it was not the PTSD of 150 years later?) became debilitating and forced Morgan to change his life. He became a book-publisher's representative in school systems in Wisconsin and Minnesota, far away from home. During this time (1870, age 34) he met and married Laura Vail of Pomfret, Vermont. In his seventh year with the firm, he suffered "a partial paralysis [which] closed his career [with the book firm]. He could neither read nor write for two years" (Kellerman 1907). He and Laura moved to her family home between the Green and White Mountains of New England.

The circumstances of his "more than three years of ... delightful recuperating of health" are unknown, but it was then that became fascinated with fungi. Surely with some mentoring, "he procured a copy of Hymenomycetes Europaei by Elias Fries" for $8.25 (Kellerman 1907) and began collecting agarics in earnest. His early gatherings were identified by C.H. Peck in Albany, NY, a fine person on whom Morgan could rely. Tuckerman and Frost also helped. He traveled to Kentucky for more collecting (Underwood 1899).

Around 1877, again feeling fit, Morgan (and wife) returned to Dayton (Ohio) where he became principal of the District High School. In the same year he published his first contribution in mycology (Morgan 1877).

C. L. Shear
with John Dearness
Gatlinburg, Tennessee, August, 1939

Fig. 15. Cornelius Lott Shear with John Dearness
[Mycologia 49(3). 1957]

Another New York State farm-boy, Cornelius Lott Shear (1865–1956; Fig. 15) matriculated at Albany State Normal School (graduating in 1888), where one

of his instructors was E.A. Burt, with whom Shear would again interact some years later. While at Albany State, he became acquainted with C.H. Peck, by then well ensconced as the New York State Botanist. They remained friends through Peck's life.

As a young adult, Shear held numerous teaching jobs but never felt any as a calling—only as a means to a "very unsatisfactory" living. Married in 1890, he taught in Alcove, New York. Avid collecting produced material for three centuries of exsiccati, New York Fungi. In 1894, he moved with his family to Osborne, Kansas, the home of his in–laws.

Mrs. Flora W. Patterson in her Laboratory

Fig. 16. Flora Wambaugh Patterson
[Mycologia 21(1). 1929]

As 19th century mycologists' timelines go, Flora Wambaugh Patterson's (1847–1928; Fig. 16) will seem familiar. Although born in Columbus, Ohio (a town rather than on a farm), she was educated in public schools, but at an age when most women undertook either a life of marriage and family or a "woman's" career (i.e. nurse, librarian, school teacher), Flora Wambaugh continued her education, graduating first from Antioch College (a small liberal-arts institution) in 1860 before earning her B.A. from Wesleyan College in 1865 and M.A. (also from Wesleyan) in 1883. Marriage to Capt.

Edwin Patterson in 1869 not only punctuated the interim between degrees but also added obligatory migration with husband and rearing their family of three boys. A few years after marriage, Capt. Patterson was seriously "injured in a steamboat explosion from which he never recovered but lived ten years, a helpless invalid" (Charles 1929).

Fig. 17. Thomas Huston Macbride
[Mycologia 26(5). 1934]

Thomas Huston Macbride (1848–1934; Fig. 17) received his B.A. (1869) and M.A. (1873) from Monmouth College, Illinois. From 1870–1878 he taught at Iowa's Lennox College, and in late 1875, married his former Lennox student,

Harriet Diffenderfer. In 1878, he moved to Iowa State University in Ames, where he stayed for 56 years.

During his lengthy Iowa State career, Macbride published on myxomycetes, but his research time must have been limited, for he served Iowa State University as Professor, President, and President Emeritus. In his later years, the faculty was joined by George Willard Martin (1880–1971) who carried the myxomycete torch into another generation.

"An eminent scientist, a profound scholar, an inspiring teacher, a brilliant public speaker, a public-spirited citizen, a lover of the beautiful in everything material as well as moral and ethical, a man of high character and a true friend, Dr. Macbride presented a rare combination of high qualities which made his well-rounded life an inspiration and a benediction." (Shimek 1934)

Fig. 18. George Engelmann
[Neilans. 1963]

In spring 1866, a sliver of light shone for Henry Ravenel. George Engelmann (1809–1884; Fig. 18) in St Louis was engaged in a monograph of *Juncus* and asked Ravenel for specimens, agreeing to pay Ravenel for weeks of collecting around Charleston. Engelmann, a highly credentialed physician and German émigré, was also an educated botanist of considerable financial means. Although his medical practice took time, he traveled in pursuit of his avocation and published taxonomic papers on selected plant groups (Humphrey 1961).

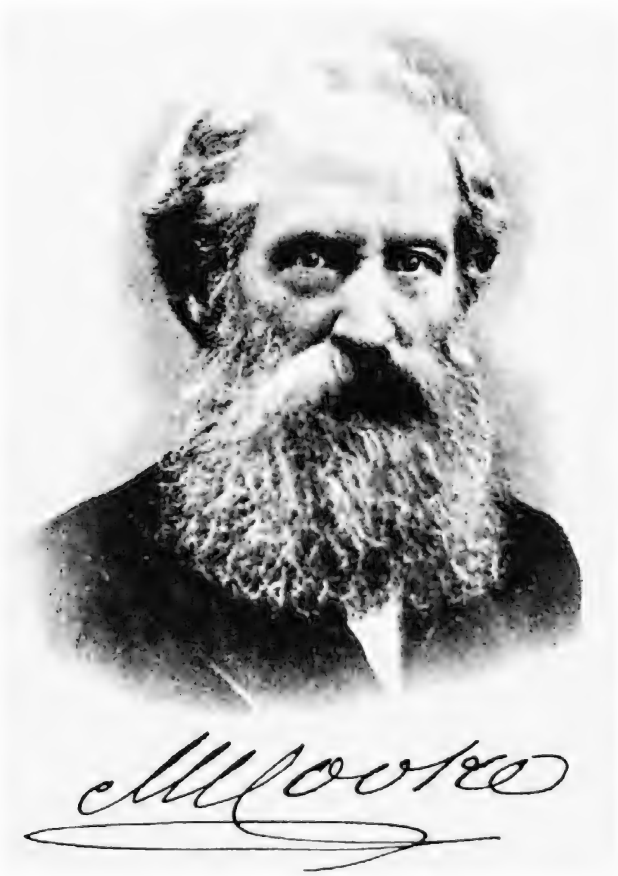

Fig. 19. Mordecai Cubitt Cooke
[English. 1981]

Engelmann's request and offer struck a spark in Ravenel, whose experience and expertise could finally be put to financial use. Ravenel undertook to write to Gray, Curtis, Engelmann, Berkeley, and others about collecting

phanerogams and seeds for sale. Berkeley spread the word, and Mordecai Cubitt Cooke (1825–1914; Fig. 19) was enthusiastic. Cooke had already published three books: Manual of Botanic Terms (1862), Plain and Easy Account of British fungi (1862), Index Fungorum Brittanicorum (1865). Also, in July came a letter from Thomas Meehan (1826–1901), a Philadelphia nurseryman. He desired seeds of native southern forest trees; Ravenel inquired about selling seeds to European individuals and gardens. Meehan responded positively, but also encouraged Ravenel to consider starting a nursery garden along the lines of André Michaux. Ravenel (after some qualms) agreed and received a large assortment of root stock from Meehan and a collection of rose cuttings from a local neighbor. He was on the cusp of yet another new career.

In 1865, only months after cessation of armed conflict between North and South, Curtis took up his pen to attempt to resurrect pre-War contacts: Asa Gray, M.J. Berkeley, Spencer Fullerton Baird (1823–1887) of the Smithsonian Institution, and others. He soon caught up with news of botany and botanists. Gray's response was especially anxiously awaited, for Curtis could not be sure of his welcome in Cambridge. Not only had Gray news, but he also reported on Charles Wright's fungus collections from Cuba (1865, but back there again) and other Mexican collections from Orizaba. All this was promptly shipped, and Curtis spent many hours examining, glad to be involved once more in fungi (Berkeley & Berkeley 1986). Baird brought news of the proposed transfer of the Smithsonian's herbarium to the Department of Agriculture, a move with which Curtis disagreed. (Petersen 1979).

Curtis's mind was still on edible fungi, however, and "In a letter to Berkeley, of England, he wrote: 'In October 1866, while on the Cumberland Mountains in Tennessee, although with little leisure for examination during the two days spent there, I counted 18 species of edible fungi. Of the four or five species that I collected for the table, all who partook of them declared them most emphatically delicious. On my return home, while stopping a few hours at a station in Virginia, I gathered eight good species within a hundred yards of the depot. And so it seems to be throughout the country. Hill and plain, mountain and valley, fields and pastures, swarm with a profusion of good nutritious fungi which are allowed to decay where they spring up, because people do not know how, or are afraid, to use them.'" (Lamson-Scribner 1893: 323).

In November 1866, former Confederate General Daniel Harvey Hill (1821–1889), then editor of a magazine in Charlotte (NC), wrote to inquire

whether Ravenel would write articles on a southern agricultural theme at $3 per page. Given this added opportunity to make ends meet, Ravenel penned several articles until the magazine was sold in 1868. Nonetheless, in late 1867, he started digging up his peach trees for sale. At the same time, a complicated arrangement for sale of fungi and phanerogams to M.C. Cooke was struck (English 1987). In his outgoing letters, a thick religious veneer concealed Ravenel's post-war anger and humiliation (to Curtis 11 Jun 1868: "In a word, I feel contented, satisfied and trusting."), but his journal revealed his rancor at his lifestyle change.

A decade or more after the Civil War, mycology in the fledgling United States consisted of a handful of men for whom the fungi were an avocation: North Carolina clergyman, southern plantation owner, Pennsylvania country doctor, and New England shoemaker. The last was Charles Christopher Frost (1805–1880) of Brattleboro, Vermont, a third-generation cobbler. After receiving corporal punishment from a teacher in 1820, Frost abruptly gathered his books and departed school, ending his formal education at age 15. But his curiosity and mental acuity were not satisfied, and over the years he ravenously digested books on mathematics, chemistry, physics, meteorology, geology, and botany and gathered collections of insects, shells, and plants. The Berkeley and Cooke manuals served as mycological foundation, but neither took up the American mycota. He and his friend, Charles J. Sprague (later to become the Curator of Botany at the Boston Society of Natural Science), together bought a French microscope. By middle age, Frost could be counted as an authority on local plants of southern Vermont and adjacent Massachusetts, and somewhat later, he began to look at and study fungi.

Even before Charles Horton Peck was hired by the New York State Museum, Charles Frost was mentoring him in mycology. In August 1866, a 61-year-old Frost wrote the fledgling Peck: "There is no elementary work on the fungi published in this country as yet that I am aware of. For their study you will have to depend on foreign wholly and they will necessarily be in Latin French & German & if you are acquainted with these languages I can recommend the following: Corda, Einleitung; Nees, System; Fries, Systema, Epicrisis, Monographia; Rabenhorst, Deutschland Cryptogamen Flora; Berkeley, British Fungi." Frost then added his recipe and method of preserving fleshy fungi. This from a third-generation shoemaker from Brattleboro, Vermont! Of course, having taught classics, including Latin (and probably Greek), Peck could use Corda, Nees, and Fries with minor effort.

The following year, Peck was hired by New York State to "fill the herbarium," and Frost continued his advice. Peck, in turn, was in touch with the aging Moses Curtis, who professed thoughts of writing his own mycological manual (Burnham 1919).

Strangely, none of Peck's biographers mention the Civil War, which raged during the years of Peck's teaching career. The immunity of Peck remains unexplained.

Charles Edwin Bessey (1845–1915), with degree in hand in 1869, became an Instructor at Iowa State College of Agriculture at Ames, Iowa, one of the early Land-grant schools. Perhaps pivotal to his career and philosophy, he spent three months with Asa Gray at Harvard in 1872–1873 and again in 1875–1876. In 1874, Bessey gave a series of lectures at the University of California, and in 1879, he earned a Ph.D. from Iowa State. Bessey was recognized for his well-known diagram depicting the evolution of angiosperms (known as "Bessey's Cactus"). His contribution to mycology was minor (with the major exception of the guidance he gave to student J.C. Arthur) but he was in touch with all the botanical leaders of the time. A second notable achievement was Charles's son, Ernst Athern Bessey (1877–1957), who in the next century would become one of North America's leading mycologists.

William Ashbrook Kellerman (1850–1908; Fig. 20) was another farm-boy from the American mid-west, this time from Ashville, Ohio. Of his early life little has been written, but the Civil War was fought during his formative years. He progressed through "country schools" and at 17 was a teacher (Humphrey 1961). How he came to matriculate at Cornell cannot be related, but he graduated in 1874, precisely at the time that Albert Prentiss arrived to chair the Botany Department, and Kellerman was likely to have had classes from him. How he secured a teaching position at the State Normal School in Oshkosh, Wisconsin, is similarly unreported, but he remained there for five years (Anonymous 1908). Married in 1876, Kellerman determined that he needed European exposure and embarked on a two year-residence (1879–1881) in Switzerland, earning a Ph.D. from the Polytechnic in Zürich (Willard 1909). Upon return, Kellerman taught at the State Agricultural School (later the University of Kentucky) in Lexington.

Later in 1881 an unusual event transpired. Ohio State University inaugurated a professorship in biology. At least three applicants were considered: Andrew P. Morgan, Joseph C. Arthur, and William A. Kellerman. Of the three,

Fig. 20. William Ashbrook Kellerman
[J. Mycol. 14(2). 1908]

Morgan, who had the thinnest credentials, was selected but—mysteriously—withdrew after three months under now-unknown circumstances but with a commendation from the Board of Trustees (Ellett 1970). The most probable

cause may have been poor psychological health, but in the meantime, Kellerman had moved to Kansas and Arthur to Purdue. Kellerman's seven years in Kansas, three on faculty and four as Kansas State Botanist, included teaching and research, the latter almost strictly phytopathological.

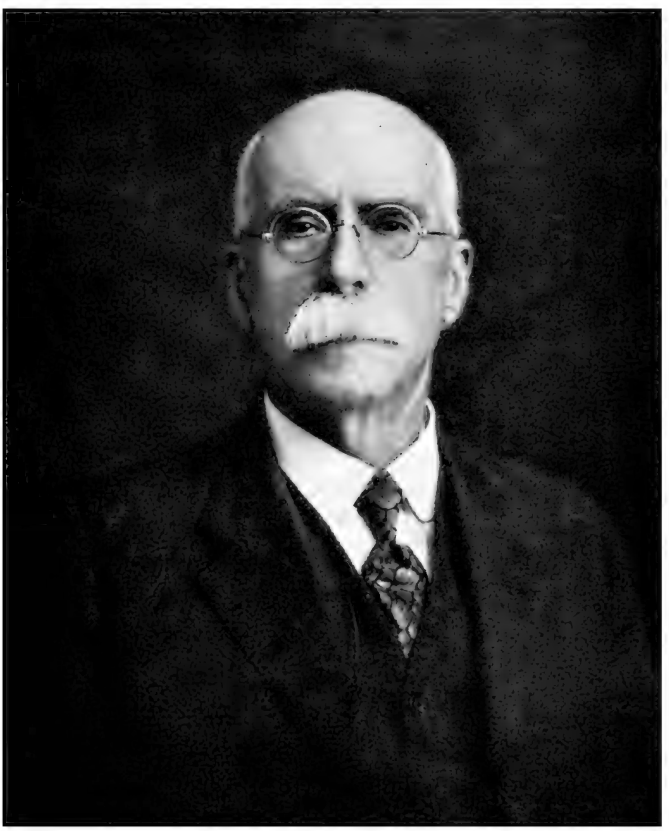

Fig. 21. Elam Bartholomew
[Mycologia 27(2). 1935]

Perhaps a stereotype of the rugged, stalwart, quiet but competent, studious American homesteader of the late 19th century is Elam Bartholomew (Fig. 21). Although he is now known chiefly as a taxonomist of plant pathogens, his influence was much more widely felt as a gatherer and publisher of exsiccati and for, as others of his ilk, his wide correspondence with the small group of established mycologists. Born on 9 June 1852 in Strasburg, Pennsylvania (situated between the Lancaster County Amish and Chester

County Quakers), Bartholomew soon moved with his family first to Ohio and shortly thereafter to Illinois. In his teens, Bartholomew decided to become a teacher, but one pre-requisite for a teaching certificate was a general knowledge of botany – something theretofore outside his worldview. He obtained a copy of Asa Gray's Lessons in Botany and before long was able to pass the qualifying examinations. Having taught for only a single school year, in 1874 Bartholomew moved to Kansas where he homesteaded a patch of land in the north-central portion of the state, but not before he was betrothed to Rachel Isabel Montgomery back in Illinois. In a whirlwind trip, they were married in Illinois in 1876 and immediately returned to Kansas. Their existence was without frills—a sod house where they raised seven children—but in addition to farming, Bartholomew was a school and town officer, active in Republican Party politics, an elder in the Presbyterian Church, and a district court clerk (University of North Carolina Herbarium 2018).

Despite his many other activities, his brush with botany had established roots. He became an earnest collector and made a herbarium with very nearly all the green plants of his neighborhood. He corresponded with several established botanists, in particular W.A. Kellerman, then of the Kansas State Agricultural College. For the rest of his life, Bartholomew would relate the following. "One day in July 1885, Dr. Bartholomew, like Cincinnatus of old, was plowing in his field when W.A. Kellerman, then professor at the Kansas State Agricultural College, came to see him. The two had never met but had corresponded much concerning phanerogamic matters. After some time Dr. Kellerman stooped down, pulled a leaf from a weed, and straightening up, said 'Bartholomew, why don't you study something that is really interesting? Look at this leaf.' It was an *Amaranthus* leaf and was covered with white pustules (*Albugo*) on the lower surface. Bartholomew did become interested and many times in later years as he developed his mycological herbarium, he was heard to remark: 'The plucking of that leaf by Professor Kellerman from a weed in my cornfield marked a turning point in my life'" (Bartholomew 1935).

In one of his columns for General Hill, Ravenel had extolled the use of the legume *Lespedeza striata* as a rotation crop for its ability to return fertility to the soil. Over the winter of 1868–1869, Ravenel received correspondence from Dr. John Shaw Billings (1839–1913) of the library of the federal Surgeon General, forwarding an offer for *Lespedeza* seed of six pounds at $5 per pound. But Billings was also interested in cryptogams and he and Ravenel discussed the contemporary French and German ideas about

causation of disease by fungi. "They [the ideas] are very amusing certainly—and if one were to believe Hallier [Ernst Hallier 1831–1904]—a *Penicillium* spore and the Darwin theory will account for pretty nearly every natural Phenomenon hitherto observed" [Billings to Ravenel, 6 Jan 1869; Ravenel papers, Clemson].

Billings also informed Ravenel of a small expedition to Texas to investigate the cause of a cattle disease. The sponsoring veterinarian wanted a botanist to look at possible fungal causes. Ravenel accepted the appointment at $300 per month plus expenses. His itinerary started in Washington, D.C., thence to New Orleans and Galveston to Houston. He finally returned to Aiken in May of the following year (1870). Ravenel's Texas plant specimens went to Torrey and others; his fungi, as pre-arranged, went to Curtis and Berkeley.

Evidence that all was not amicable in the wake of the War is reflected in a remark by Elliot C. Howe (1828–1899) of New York State (another mentor to Charles Horton Peck), who had been approached by Ravenel in 1868. Howe confessed to Peck, "I will send [specimens for identification] to Ravenel this week, though I confess to a feeling akin to horror at the thought of addressing a South Carolinian! But our science must not suffer though we are compelled to invoke the aid of Le Diable himself" (Haygood 1983: 344; Petersen ined.).

Lucien Marcus Underwood (1853–1907; Fig. 22) was born in Woodstock, New York, not far from the homes of J.B. Ellis and C.H. Peck. As a child he made collections of grass leaves and of rocks and minerals (Hesler 1975). "As he learned to read and write, he became interested in collecting papers and documents of all kinds and would prepare lists of celebrities and of events. Later, when his school days brought him in touch with natural science subjects, the house became the repository of rocks and minerals and the laboratory for such physical and chemical experiments as his ingenuity could devise" (Curtis 1908). He was clearly too young to be affected by the Civil War. From age 5 to 11, Underwood attended summer sessions at "the brick schoolhouse," and at 11 he became a farm hand. At age 15, he attended Cazenovia Seminary. The school was three miles from home and, of course, he walked both ways. In 1868 or 1869, he was "forced to take over the home farm" (Hesler 1975): typical[ly] farming in summers, lumbering in winters (Curtis 1908).

The year 1873 found him back at Cazenovia Seminary. Although he had yet to overcome difficulties in public speaking and writing, a teacher suggested college and later that year Underwood enrolled at Syracuse University. During summers he worked on farms in the area, saving enough money to visit New York City and the Philadelphia Centennial Exposition, his first peek at

Fig. 22. Lucien Marcus Underwood
[Bull. Torrey Bot. Club 35(1)]

the outside world (Curtis 1908). At Syracuse, Underwood "… soon became dissatisfied with the scientific course because [it was] deficient in the amount of work required and after seriously considering the advisability of completing the college work in three years, he finally decided to enter the Latin-scientific course although this necessitated the preparation of six books of Virgil, four orations of Cicero, Sallust, Roman History, and Latin Prose." (Curtis 1908) [His cause for change must have been rare in that day and even rarer in 2019.]

Upon graduation in 1877, Underwood accepted principalship of the Morrisville Union School for an annual salary of $700. In 1878, he completed one year of post-graduate classes at Syracuse and purchased Hooker's Synopsis Filicum. During the 1878–1879 school year, Underwood taught natural science back at Cazenovia Seminary. In winter sessions he taught 14 classes a day, receiving a salary of $600 for the year. In these years His interest, which at the time focused first on ferns and then on hepatics, gradually migrated to fungi.

Fig. 23. Franklin Sumner Earle
[Mycologia 2(1). 1920]

Born 4 Nov. 1856, on a large fruit farm near Dwight (now in Livingston Co., Illinois), Franklin Sumner Earle (1856–1929; Fig. 23) showed interest in plants and animals early on, supported in his hobby by his mother. At 16 he prepared for college and attended the University of Illinois, but his studies were interrupted periodically by exigencies at the family farm, and Earle spent four years assisting his father uninterruptedly. Again in 1878 he attended the

University and came under the guidance of Prof. Burrill but had to withdraw within a year. (Shear 1929) This brush with college-level education was to end his formal education.

In 1892, Earle was appointed superintendent of one of the branches of the Mississippi Experiment Station, but his penchant for research led to a position as assistant pathologist in the USDA herbarium in Washington (Chardon 1929). In this position, Earle was primarily a phytopathologist, a discipline that engaged him for the rest of his life. He had also been introduced to tropical climate and flora with their pathological susceptibilities.

Curtis Gates Lloyd (1859–1926; Fig. 24) was also born just before the war on 17 June 1859 in Florence, Kentucky, moving with his family to Crittenden

Fig. 24. Curtis Gates Lloyd
[Photo origin unknown]

when he was nine. Typical for the era, he attended country schools and never enrolled in any college or university. "Whether or not this latter fact influenced him to chide the professors or not can hardly be established." (Hesler 1975)

As he neared puberty, Lloyd became acquainted with the medicinal plants surrounding him and discovered that his harvest, when correctly prepared, could be sold to a pharmacy. Lloyd and his brothers established a successful pharmacy of their own and expanded the business into nearby Cincinnati, Ohio, as the Lloyd Brothers Pharmaceutical Company. The company grew and prospered (thanks largely to the efforts of his brothers) while Curtis Gates devoted time to avocations, including global travel.

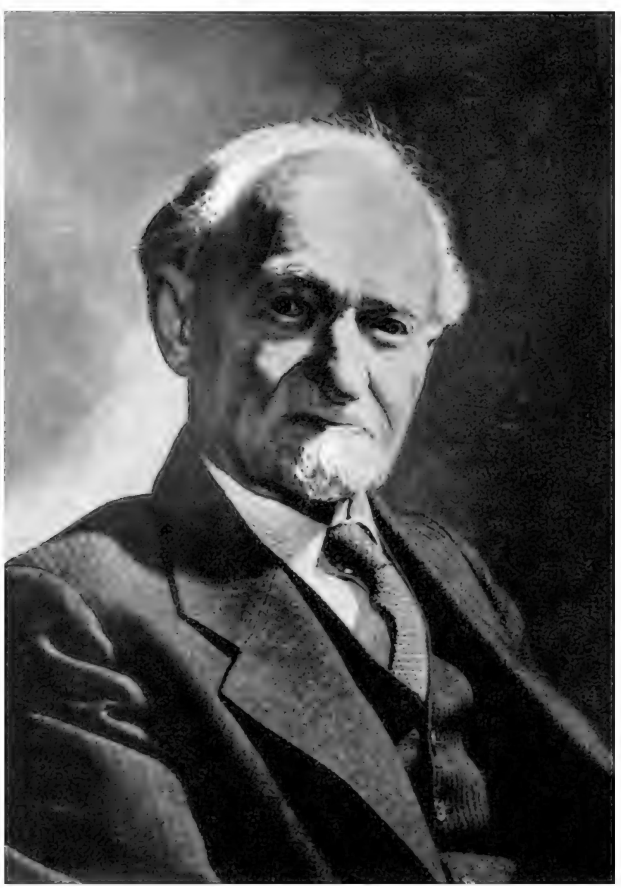

Fig. 25. John Dearness on his 80th birthday
[Mycologia 47(1). 1947.]

In "far-off" Canada in 1872, John Dearness (1852–1954; Figs 15, 25) passed a three-month course at Toronto (Ontario) Normal School and became Principal at Lucan village school. The following year saw him Principal of Strathroy Public School and in 1874, he was appointed Public School Inspector of East Middlesex (a position he held for 25 years). Much later (1899–1914) he was Professor of Biology, Medical School of Western University. He was to become an "early" Canadian mycologist.

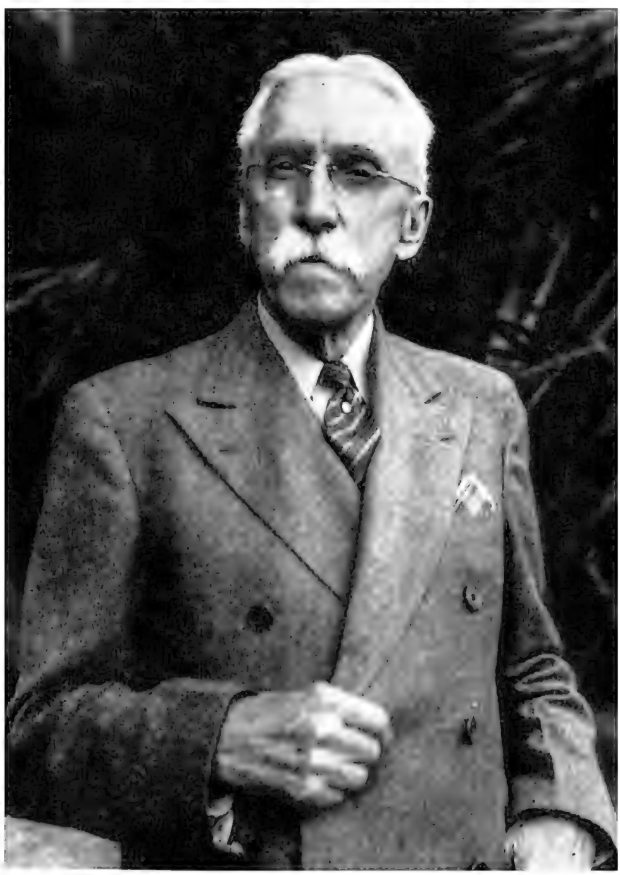

Fig. 26. Joseph Charles Arthur
[Phytopathology 32(10). 1942]

Although born in rural New York State on 11 January 1856, Charles Joseph Arthur (1856–1942; Fig. 26) and his family moved to northeast Iowa when he was six. As could be expected, Joseph (as he was known to distinguish

him from his father, Charles) passed through public schools through high school in Floyd County. Embarrassed by mix-ups in his name in school, he informally changed it to Joseph Charles in adulthood. Upon graduation, Arthur was sent to the newly created Iowa State University (1869) in Ames where he already planned a career as a botanist. He was disappointed that there were no botany courses in the new school, but coincidentally, Charles E. Bessey arrived in 1870, and a match was made. Graduation soon followed with a B.S. and after a short pause, an M.S. in 1877.

Arthur's obduracy with what he considered senseless university requirements became troublesome, specifically, "In 1872, the American Association for the Advancement of Science [AAAS] met at Dubuque, Iowa. The great botanist, Asa Gray, was to be a speaker. Of course, a budding botanical student desired to be there. In fact, he just had to go. But the college authorities did not think it wise and would not give their approval to his petition to be absent long enough to attend the meeting. No amount of persuasion changed their verdict. What did our independent, ambitious student do? He went. And he graduated a little later, but many amends had to be made." (Kern 1942)

Enter a powerful player in politics but also a small but pivotal role in mycology. George William Clinton (1807–1885; Fig. 27) was born of an illustrious family: his father, Dewitt, was a famous inventor and recent governor of New York State. George had a bent for natural history and as a student of 19, he was permitted to join an academic journey through the full length of the brand-new Erie Canal, opened in 1825. The teacher for this endeavor was Amos Eaton, author of several botany texts. The experience reinforced Clinton's natural history leanings. Time passed: Admitted to the bar in 1831, Clinton forged a career as a prosecutor and judge. Always involved with natural history, he was elected the first president of the Buffalo (NY) Society of Natural History, and later a member of the New York State Board of Regents, one duty of which was to oversee the State Museum. All the while, he maintained an enormous correspondence with naturalists both domestic and foreign, one of whom was Charles Horton Peck.

In about 1878, Andrew and Laura Morgan moved to "the little farm in Preston [Ohio] for twenty-three years" (Kellerman 1907). His collecting, mushroom studies, and interaction with Lloyd continued. "In the case of the more fleshy fungi it is Mr. Morgan's practice to preserve only a painting. His collection

Fig. 27. George William Clinton
[Neilans. 1963]

contains many hundreds of these all made by the hand of Mrs. Morgan who has aided in bringing together a most valuable collection" (Underwood 1899).

During 1867, Peck contributed his botanical skills as a volunteer part-time at the State Museum. He was distraught when Cass's Academy announced that it would close at the end of the term due to financial difficulties. How would he support his family? He appealed to Judge Clinton to promote a government allocation in the state budget for a botanist. Clinton did so, and in 1867, a

position was created for a worker to help "fill the herbarium." Peck, of course, was pleased to be able to pursue botany full-time, but the position was an annual item—easily erased by omission or reallocation of funds. Not until 1883 was the title of "State Botanist" made permanent (Haines 1978; Petersen 1980b; Lloyd 1912).

Not immediately did botanist Peck understand that of all the plants of New York, the least represented in the herbarium were the fungi. It took a couple years and urging by a learned amateur mycologist and mentor, Elliot Howe, before he began to investigate the group, and it was in that period that Frost also lent his advice.

Although born in Vermont, Elliot Calvin Howe (1828–1899; Fig. 28) came to New York State early in life. Educated in Troy and Lansingburgh, he had strong interests in natural history and music (not unlike William Farlow a generation later).

Early in life he gave indications of a love for natural science and turned his attention to the study of geology, zoology, and botany. Music (piano) also received a significant share of his attention. Pharmacy was also attractive to him, which soon led him to the broader field of physiology and medicine. While engaged in medical studies in New York City, Howe did literary and reportorial work for the New York Tribune, then under the management of its celebrated editor, Horace Greeley. After receiving the M.D. he returned to Troy and commenced the practice of medicine. Music remained a strong avocation and Howe wrote numerous pieces of popular music, of which one, "The Wanderer's Dream," was played by the musicians of both armies during the Civil War, a unique contribution to the war effort.

After a few years, Howe was induced to leave Troy to enter the large and flourishing Charlotteville (NY) seminary as teacher of music, physiology, and botany. His job was abruptly terminated when the seminary building burned to the ground, but he quickly moved to Fort Edward Institute where he taught music, botany, and German. There he met Miss Emily Z. Sloan, also a teacher at the institute, who afterward became his wife.

While at Fort Edward Institute, Howe also began the study of fungi and entered into correspondence with M.A. Curtis of North Carolina, who at that time was the chief devotee and exponent of American mycology. Also during this period, "he directed the attention of [C.H. Peck] to the interesting features of mycology and induced him to enter this field of botanical investigation, which at that time was almost a terra incognita in this country" (Peck 1899).

Fig. 28. Elliot Howe
[Neilans. 1963]

After seven years Howe left Fort Edward to renew a medical practice in New Baltimore (NY), but the field there was limited, and he soon moved to Yonkers (NY), just north of New York City. His biographer (Peck) does not explain the circumstance, but seven years before death, Howe became a quadriplegic, and thereafter was confined to his home, a helpless invalid. On March 2, 1899, "he fell asleep and a varied and useful life was closed" (Peck 1899).

In 1869, John Torrey informed Ravenel of two possible academic positions (University of California and Washington University in Kentucky). Ravenel demurred from both possibilities (and no offers were made), using deafness

as an excuse. By the end of 1869, moreover, he was more sanguine about his life and circumstances—certainly, life had improved substantially since the end of the war. But former botanical relationships based on free exchange now had to turn financial. This was difficult in some instances.

By 1872, he resumed correspondence with J.B. Ellis, who apparently connected Ravenel with F. von Thümen (initially in Germany; then from 1876, in Austria), who desired specimens from America for his (Thümen) exsiccati, Mycotheca Universalis (Stevenson 1971: 448–459). Ravenel expected financial return for the specimens submitted through Ellis ($6.00 per hundred). Ravenel specimens appeared in centuries VI (1876) through XXII (last, 1884). Decades later, Stevenson (1971) identified several type specimens from among Ravenel collections.

On April 10, 1872, Moses Ashley Curtis died suddenly, bringing finality to the long correspondence between Curtis and Ravenel (and numerous others). Curtis's post-war financial existence had been somewhat precarious, especially considering the expenses of specimen shipments to Berkeley. Although the congregations around Hillsboro, North Carolina, that were serviced by Curtis did their best, there certainly was little money left over to pay their minister. In contrast, his friend and coworker, Ravenel, had significantly changed his lifestyle from plantation owner with numerous slaves to entrepreneur selling his botanical expertise and experience.

Reconstruction

Abraham Lincoln issued the Emancipation Proclamation during the Civil War, and the War had put the proclamation into practice. The result was anything but smooth. A holistic set of laws and unwritten etiquette conspired to mire Blacks in the lowest caste position. Although usually remembered as laws that excluded Blacks from public transport and facilities, juries, jobs, and neighborhoods, passage of the 13th, 14th, and 15th Amendments to the Constitution actually afforded Blacks the same legal protections as whites and women. However, after 1877, and the election of Republican President Rutherford B. Hayes, southern and border states began restricting the liberties of Blacks. Unfortunately, the Supreme Court helped undermine the constitutional protections of Blacks with the infamous Plessy v. Ferguson (1896) case, which legitimized "Jim Crow" laws and the "Jim Crow" way of life.

In 1877, Ravenel (in his journal; Arney 1947) planned a trip to Georgia and Florida to collect all cryptogams for subscription, the proceeds of which

would add to the household income. M.C. Cooke in London advised Ravenel (in detail) on methods of preservation. "Cooke will attend to the fungi, Tuckerman will take lichens." Cooke's involvement was in answer to Ravenel's inquiry about the possibility of selling fungus collections from the southern United States, suggesting that Cooke might have been the instigator and executor of the exsiccati plan. Ravenel's trip took place, and Cooke announced the exsiccati in December 1877. "The series will be edited by M.C. Cooke, and each century will be issued when it is ready. As only a small number of sets will be made up, early application to the Editor of this Journal [Cooke, Grevillea] is desirable" (Stevenson 1971: 307). Indeed, century 1 of Fungi Americani Exsiccati was issued from London in 1878. The series would extend to 1883 (century 8), and the final payment to Ravenel came promptly that year—$42.

Although the decade from 1865 to 1875 saw the emergence of William Gilson Farlow (1844–1919; Fig. 29) as a cryptogamist, only at the end of that time did Farlow begin to emphasize the fungi. His overall contribution to mycology in America was (and is) so significant that a somewhat lengthy sketch of his timeline seems warranted.

A venerable and well-endowed institution, Harvard University was not a place for second-echelon students and/or impecunious families unable to pay the tuition. But Harvard also had an appreciation of prominent families of means and when above-average intellect was matched with financial resources, at least admission, if not graduation, was probable. So when John S. Farlow, the successful businessman (Linder 1945), avid prize-winning horticulturalist, prominent politician, and President of the Boston Handel and Haydn Society recommended his son, William, to the University, Harvard welcomed the young man, even though he had received his previous education from public schools. William, like his father, had two strong interests: botany and music. The first was exhibited in William's courses with Asa Gray, who singled him out and co-opted his help in the classrooms. The second prompted another teacher to suggest a professional career in music. As an undergraduate, William's years at Harvard (1862–1866) continued to impress Gray, especially as Farlow's focus was on the "lower" cryptogams—algae, mosses, fungi. [Setchell (1927) sketches the state of botany in the U.S. during this time period.] But when William began planning a career in botany, Gray forcefully advised a more dependable, lucrative profession to which botany could be appended as an avocation. Examples were Torrey and

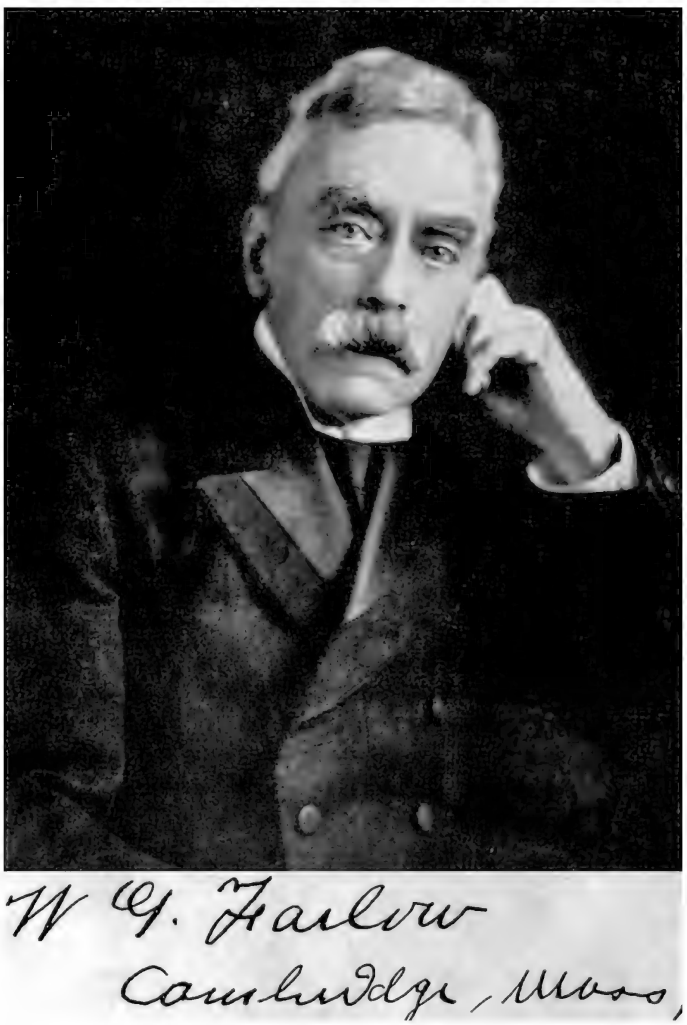

Fig. 29. William Gilson Farlow
[Mycol. Notes (Lloyd) 40. 1916]

Gray, both with medical degrees. Following Gray's advice, Farlow earned a medical degree from Harvard in 1870. Instead of entering practice, however, Farlow returned to Gray's laboratory as an official assistant.

Just then, Farlow's interest was focused on marine algae. The summer of 1871 was spent at Woods Hole (Massachusetts), the marine biology station, in the company of outstanding algologists from all over the nation. At the

same time, Charles Wright brought a cache of algal specimens from Cuba, which Gray passed on to Farlow and which formed Farlow's first publication (Farlow 1871).

Shortly thereafter, Gray again persuaded Farlow, this time to consider a European exposure to the leading botanists and laboratories. There ensued a two-year grand tour through (at least) "England, the Scandinavian countries, Russia, Germany, France, Italy, and Switzerland" (Harris 1945, Weston 1945). There was no anxiety about finances, and Farlow bought numerous rare books, returning also with an armful of specimens, mostly algae. During his absence, in 1872 Gray purchased Curtis's herbarium on behalf of Farlow. Upon return, Farlow was appointed Professor of Cryptogamic Botany, with duties split between Cambridge and the Bussey Institution (Harvard's subsidiary of Agriculture and Horticulture) in nearby Jamaica Plains.

Soon, Farlow was relieved of his Bussey duties and the Professor took charge of teaching Cryptogamic Botany. He was able to introduce teaching methods observed in Europe, including those of H.A. de Bary: microscopes used in class and plant specimens inspected in lab—new to botanical teaching but soon tried in other schools.

"In [physical] stature, Farlow was decidedly below the average, a matter concerning which he was somewhat sensitive, especially when associated with one which was taller. He seldom, however, made reference to it except through some witticism" (Setchell 1927). Otherwise, his energy and volubility made his lectures enjoyable, and he spent long hours sorting specimens together with graduate students and hangers-on. Farlow's focus shifted to fungi and he began especially to consider parasitic fungi, especially plant pathogens. He professed that there were three requirements for teaching cryptogamic botany: 1) an herbarium of authentic reference specimens, 2) an extensive and complete reference library, and 3) an index to keep track of the first two. With student help he began projects in all three.

Elsewhere, the year 1874 saw a catalog of New England "boleti" by the learned shoemaker, Charles Frost (Frost 1874). Although one of only a handful of Frost publications, the paper must have had the imprimatur of Peck, considering their friendship and the Buffalo journal in which it appeared.

Spurned from a hitch in the army in the Civil War, Albert Prentiss pursued a career through educational jobs in public schools until he was appointed to the faculty of the University of Nebraska for some years. Among his students

were C.E. Bessey, W.P. Wilson, B.D. Halsted, and S.M. Tracy, all of whom went on to produce meaningful mycological contributions. In 1868, not only did Cornell open to students, but Prentiss made his way there as Head of the new Department of Botany and director of campus grounds. The first course was offered to an enrollment of four, but by the next term, attendance swelled to 144, a token of his teaching abilities.

Far from a country bumpkin, Prentiss was refined, sophisticated—and widely traveled. In 1870, he banded some students together to join "The Cornell Exploring Expedition," investigating the natural history of the Amazon River in Brazil for six months. Two years later, he traveled to Europe to study in the herbaria at Kew and Paris. During these years his health began to deteriorate, and he was obliged to reduce his duties supervising campus grounds. But he remained engaged in the classroom and with graduate students who were numerous, bright, and destined to careers in botany. After his retirement in 1885, he was succeeded by George Atkinson. Prentiss died in Ithaca on August 14, 1896 (Atkinson 1896; from an entry apparently written just before Prentiss's death).

Mycologically, all was not dark in Europe while the Americans increased their contributions. After all, Fries (the "father of mycology") was still alive and almost fully productive right up to his death in 1878. But even during his lifetime other European workers proposed new schemes of fungal classification. Léveillé (1846), well-known for his work in the South Seas, produced a new organization. De Bary (1866), with whom Farlow studied, added a new classification. In Great Britain, Berkeley's Outlines of British Fungology (1860) purported to be aimed at the British Isles but in many ways actually covered the whole mycological world. Berkeley was succeeded by M.C. Cooke, whose Introduction to the study of fungi (Cooke 1895) was even more comprehensive and popular. Cooke's multivolume Illustrations of British fungi (Cooke 1881–1891) brought excellent images to those who could afford them.

Although his work was hardly known in English-speaking North America, Carlos Luis Spegazzini (1858–1927; Fig. 30) was busy collecting fungi and describing what he found in Argentina. Born in Acosta, a small town near Turin, Italy, Spegazzini took special interest in fungi and was friends with Beccari and Pier Andrea Saccardo. He would follow Saccardo's system of classification for his lifetime.

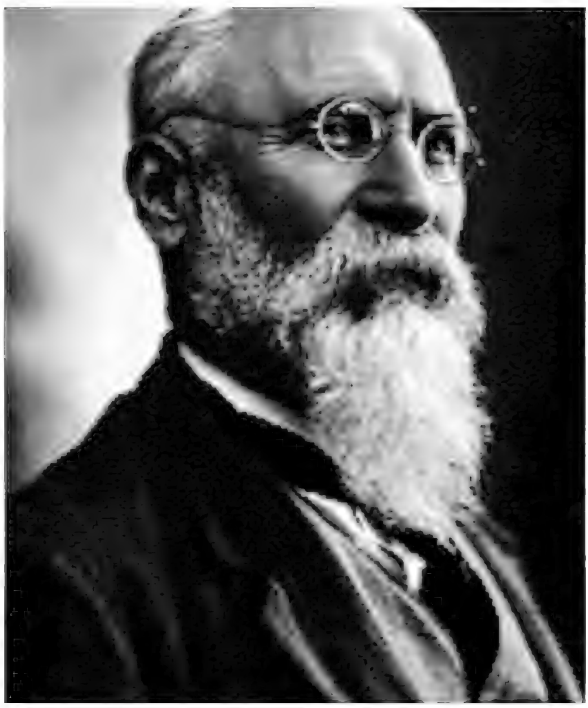

Fig. 30. Carlos Luis Spegazzini
[Origin unknown]

In 1879 (age 21), armed with a diploma from Collegio Real de Viticultura y Enologica, Spegazzini embarked on a trip to South America where settlements of Italians already existed. After a stop in Brazil, he disembarked in Buenos Aires on Rio de La Plata, Argentina. The locality was to be his home for life.

Repeated expeditions to remote parts of Argentina resulted in lengthy descriptive publications of the fungi found wherever. In several ways, Spegazzini's role in Argentina mirrored Peck's role in the United States—each a pioneer in his field, each describing hundreds of new species, and each remaining in place and productive for many years. Had Spegazzini written in English, perhaps his work would have been appreciated in the Northern Hemisphere, but he was greatly celebrated in Argentina and his herbarium is preserved at the Spegazzini Institute in La Plata (Anonymous undated, Murrill 1924, Anonymous 2010, Macjus 2013).

In a day when support groups were not formalized, family was of supreme importance when death overcame a spouse. After the death of her invalid husband, Flora Patterson moved to Ames, Iowa, where her brother taught at Iowa State University and she earned a second M.A. in 1895. As her boys grew, her brother was offered a position at Harvard Law School. The circumstances of her migration are lost, but in 1896, she was teaching in a Boston, Massachusetts, private school. Flora took the opportunity to study in the Gray Herbarium at Harvard.

Stationed in Boston and her boys coming of age, Patterson was determined to continue her studies at nearby Yale University in Connecticut. "Thinking all conditions for pursuing work at Yale had been arranged, she went there only to find the doors closed against her, women not being eligible at that time. In spite of the keen disappointment and inconvenience she persisted in her desire to continue botanical investigations, and, [returning] to Cambridge, registered for work at Radcliffe College. There she remained for three years, 1892–1895, taking courses in botany and working as an assistant in the Gray Herbarium" (Charles 1928).

Ellis & Everhart

During his hitch in the navy, J.B. Ellis had, as usual, complained about the climate in Potsdam, New York. A chum suggested the unlikely town of Newfield, New Jersey, as possessing a pleasant climate. Ellis investigated the place and wound up settling there for the rest of his life. During 1877–1878, Ellis decided to drop all other pursuits to issue an exsiccati entitled Fungi Nova-Caesareenses, comprising ten sets of New Jersey fungi. He sold two sets, one to Farlow (Harvard), the other to Mr. Isaac C. Martindale. At the urging by Martindale these sets were recalled and renamed as North American Fungi (Anderson 1890, Stevenson 1971).

With these words as entré, some additional thoughts on exsiccati seem appropriate. The idea was early developed that specimens (of anything) could be exchanged among like-minded enthusiasts. But when a single specimen proved interesting to more than one worker, the idea of sets of labeled specimen multiplicates, which could be sent (gratis) or sold (a derivative idea) became attractive, and these compilations took on the name "exsiccati."

In all exsiccati with named specimens, the specimens are only as valuable as the identifications appended to them. Thus, specimens of powdery mildews identified (or named as new) by Ellis (the American expert at the time) take

on more "authenticity" than those of most agarics (some, originating from North America, were identified by M.C. Cooke from England without any geographical caveats and assuming that American taxa and European taxa could be labelled with the same names—all too common even now). Therefore, exsiccati specimens are candidates for basic taxonomic research—not to be treated as "deo volenti."

Ellis had been exposed to the concept (and, as it turned out, to mycology as a whole) when he saw a broadbill announcing Ravenel's exsiccati. Years later he exploded the concept to theretofore unheard-of size. The issuance of exsiccati multiplied apace and by the last years of the 19th century there were scores of exsiccati available from and representative of several European countries and American states. The specimens were heavily of fungi that could be pressed and dried, including gasteromycetes and manageable polypores (those which could be pressed or sliced so as not to take up excessive space). Hymenomycetes were more difficult to preserve and lost most of their shape, stature, and color. Ancillary notes on these characters must accompany such specimens.

In Ellis's case, between North American Fungi [36 centuries in two series: as sole author centuries 1–15 (starting in 1885) and with B.M. Everhart centuries 16–36 (1886–1896); assuming c. 50 subscriptions totaling 180,000 specimen packets] and Fungi Columbiani [centuries 1–51 (starting in 1891; and with century 14 by C.L. Shear), and centuries 15–51 (ending in 1917) by Elam Bartholomew in Kansas; using the same calculation totaling 255,000 specimen packets], a total of 435,000 specimens were added to North American and European herbaria.

In a cameo performance, Benjamin Matlock Everhart (1818–1904) was not a mycologist—at least not by education or profession—although that opinion was not universal. "He is one of the best mycologists that America has ever produced, having done much good work with Mr. Ellis in the description of new and rare plants" (Harshberger 1899). Born May 24, 1818, in Chester County, Pennsylvania, Everhart and his family were neighbors of (and perhaps fellow Quakers with) of Ezra Michener and Dr. William Darlington. After the usual rudimentary education at West Chester Academy, Benjamin worked in the family's general store (eventually succeeding his father) and built a "comfortable fortune" (Harshberger 1899, Kellerman 1904, Hesler 1975). A glimpse of Everhart was offered by Harshberger (1899), who visited him in 1895. "Having kept a general store in West Chester, in which he took much

pride, Mr. Everhart amassed a considerable fortune, and is looked upon as one of the wealthiest men in West Chester. By his neighbors he is considered rather unapproachable and peculiar, as a man ready to push a close bargain. In person Mr. Everhart is a man of striking appearance; his nose is aquiline, his forehead low, his beard is scant and fringing, his eyes are bright, and his smile pleasant. At the age of seventy-seven he is still a man of considerable activity, although slightly deaf" (Harshberger 1899: 227). Everhart had a strong avocation—natural history—and was a collector of plants, birds, and insects.

The details of how J.B. Ellis first interacted with B.M. Everhart have been lost, and their initial correspondence dealt only with the cost of specimens. Most likely Everhart heard of or saw a century of Ellis's exsiccati and therefore initiated contact. Nonetheless, as their association developed, Ellis may have told Everhart of the financial obligations inherent in issuing large numbers of exsiccati specimens. Everhart, the businessman, perhaps saw an opportunity to underwrite Ellis's efforts for the good of natural history and perhaps receive the products, and it has been said that thereafter Ellis provided the specimens while Everhart provided the money. He also collaborated in the publication of Ellis's major monograph on *Pyrenomycetes* in 1892, and his name is on the title page as co-author.

Because of the heavy emphasis on those fungi which Ellis knew well, the exsiccati include many type specimens as well as contributions from numerous collectors across the continent. Attribution for identifications included most of the leading mycologists of the day, including European, and specimens represent all classes of fungi (of the time).

In 1899, Arvilla, Ellis's wife died, putting responsibility of total exsiccati work on J.B.'s shoulders, and the task soon proved overwhelming. As Ellis's biographer wrote: "Many years ago she began aiding her husband, Mr. J.B. Ellis, in the arduous labor of preparing and mounting the specimens for the North American Fungi and later for the Fungi Columbiani, and with her own hands bound the books in which these were delivered to subscribers. Had it not been for her help, the first of these great distributions (numbering 3,600 specimens) would have been suspended early in its history, and the second (numbering 1,400 specimens) would never have come into existence. To her deft fingers, which wrought so patiently, botanical science is indebted for the more than two hundred thousand specimens of the fungi which Mr. Ellis distributed to the botanists of the world" (from Science Aug 11, 1899; Kellerman 1906).

It must have been sometime after 1878, around the time Andrew P. Morgan and wife Laura moved to a farm in Preston, Ohio, that C.G. Lloyd began interacting with Morgan, to whom Lloyd attributed his introduction to the study of fungi.

The details of Lloyd's "retirement" from the family business are hazy, but he withdrew from active service only to continue receiving the income of a partner. This enabled him to travel at will, including trans-Atlantic tours, and to begin production and dissemination of his own publications on fungi, which began in 1898 and filled seven volumes to 1925 (Stevenson 1933). It can be reported that Lloyd was mycologically self-taught, but more than that, Morgan, his mentor, was also self-taught. This inevitably left lacunae in Lloyd's "education," but how this affected his personality cannot be known.

Elam Bartholomew's interaction with W.A. Kellerman kindled a fresh fire in Bartholomew. Soon he was collecting and identifying plant pathogens and, as was typical, began a herbarium. His circle of correspondents changed somewhat, expanding to include the mycological luminaries of the day: Peck, Ellis, Holway, Arthur, Bethel, Dearness, and others. Introduced to the concept of specimen exchange through exsiccati, in 1901 Bartholomew endeavored to publish and disseminate the exsiccati series Fungi Columbiana originated by Ellis and Everhart (36 centuries by 1917). In 1911, he began his own exsiccati, North American *Uredinales,* which over the years extended to 35 centuries. Work on his Kansas farm went on unabated, but as his reputation spread, Bartholomew received invitations to join faculties of colleges and universities. These were consistently refused. He gave as his reason for refusal that he preferred to work in private on the farm which he had homesteaded in the waning days of the buffalo and antelope (Bartholomew 1935). Eventually in 1929, however, he and Rachel moved to Fort Hays where he became curator of the herbarium. There they remained until his death, 18 Nov. 1934 (Kansas Historical Society 2018).

Not a prolific publisher, Bartholomew contributed some summaries. His specialty became the rust fungi, which were common and diverse in Kansas. The plant rusts of Kansas and especially his Handbook of the North American *Uredinales* were comprehensive, with the Handbook announced and reviewed by the leading uredinologist of the day, J.C. Arthur (Arthur 1934a). Bartholomew filled two important roles in the mycology of the late nineteenth and early twentieth century: 1) his ardent collecting and exsiccati exchange furnished specimens to a wide audience, and 2) his hitherto

unexplored Kansas location gave a hint at the plant–fungus associations of the Great Plains.

1896 found F.S. Earle, now Biologist and Horticulturist of the Alabama Experiment Station [to become the Alabama Polytechnic Institute in 1899 and in 1960 Auburn University], "and it was here that Professor Earle came into close personal touch with the eminent mycologist George F. Atkinson" (Chardon 1929). Almost surely untrue (or misleading), for Atkinson served on the Alabama faculty during 1889–1892 and by 1896 had returned to Cornell. But as Atkinson also collected in Alabama on subsequent field trips, interaction might have been possible at those times. Lucian Underwood, also at Alabama during 1895–1896 before migrating to Columbia University in New York, probably also met Earle.

Except for his 1901–1904 sojourn at the New York Botanical Garden as curator of the mycological collections (where his interest turned briefly to agarics), Earle never again deviated from plant pathology. With a rich library and time for research, Earle amassed what became a seminal work, albeit largely overlooked for many years, The genera of the North American gill fungi, which appeared in print after his departure as a Bulletin of the Garden (Earle 1909). Previous more focused papers (Earle 1902a,b,c) also reflect some interest in agarics.

"Being himself a member of the old school, he ventured to cover too wide a field in taxonomy. Thus, while specializing on the *Agaricales* on one hand he also tried to cover such widely diverse groups as the tropical species of *Meliola*, the *Hypocreales,* the *Xylariaceae,* and all the groups of the *Fungi Imperfecti*" (Chardon 1929).

Born during the Civil War, but far away from the front, Robert Almer Harper (1862–1940; Fig. 31) came into this world the son of a minister in Le Clair, a tiny town on the shore of the Mississippi River, just inside the Iowa border with Illinois. His parents apparently had a high regard for education, and Robert graduated from Ohio's Oberlin College in 1886 at the age of 21.

For two years Robert Harper taught Latin and Greek at Gates College, Nebraska, but moved on to study at Johns Hopkins University in Baltimore, Maryland. His formal education sent him to the Strassburger laboratory in Bonn, Germany where he was awarded a Ph.D. degree in 1896 (age 34).

Harper's credentials, including a German doctorate, earned him an appointment as Professor and Head of the Department of Botany at

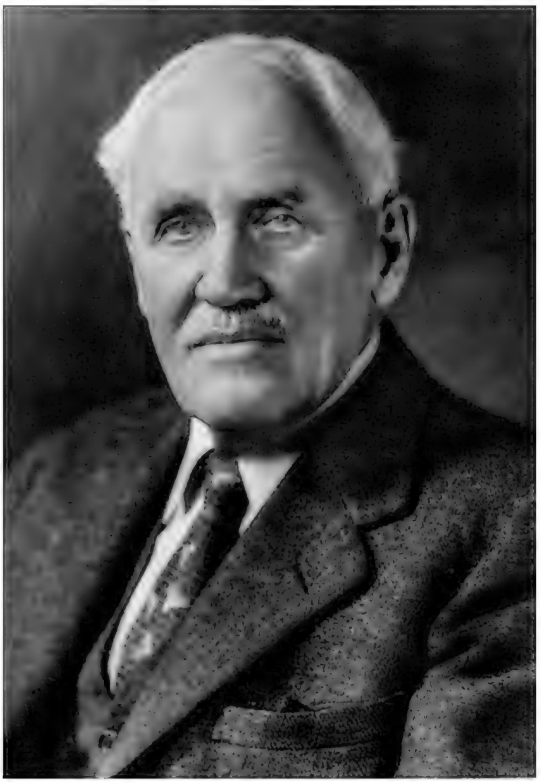

Fig. 31. Robert Alman Harper
[Bull. Torrey Bot. Club 69(5). 1942]

Wisconsin University, where he served for a dozen years (1896–1911). His enthusiasm for field trips was evident and he reveled in the richness of the local flora.

In 1885, George Francis Atkinson (1854–1918; Fig. 32) at 31 years of age, emerged from Cornell University with a B. Phil. (now considered a B.A.), ultimately to be his highest earned degree. He had been born in mid-winter 1854, in the hamlet of Raisinville, Michigan, not far from Maybee and southeast of Ann Arbor. The Civil War had been fought far away during his early years, and his teenage activities are no longer known, but in his 24th year (1878) he enrolled in Olivet College (Eaton Co, Michigan), a small liberal arts abolitionist institution founded in 1845 to educate students regardless

Fig. 32. George Francis Atkinson
[Cornell Plant Pathology Herbarium]

of gender, background, or financial need). There he took some courses but was soon after admitted to Cornell as a junior (Humphrey 1961). Possibly these undergraduate experiences prompted him later to write several books intended as an introduction of botany to fledgling students.

Armed with his formal degree, Atkinson embarked on a whirlwind revolving-door tour of southern educational institutions. The first was the University of North Carolina (three academic years, 1885–1888). Next was the University of South Carolina (a single academic year, 1888–1889), then to a newly created position as Professor at the Alabama Agriculture and Mechanical Institution (now Auburn University) for three academic years, 1889–1892). In all these positions he focused professionally on plant pathology, but he was able to insinuate some publications on much wider subjects, including entomology, zoology, ornithology, and botany. Fresh from Alabama (where he had been awarded an honorary M.A.) Atkinson accepted a position as Assistant Professor of Botany at his alma mater, Cornell (1892–1918), replacing William R. Dudley who migrated to Stanford University in California. Atkinson was promoted the following year. In 1896, upon the death of Albert Prentiss, Atkinson succeeded as Department Head. Although he might not have known, Cornell was to be his final career home.

Educationally, Flora Patterson's credentials were superb, but the opportunities for using her extensive training equal to men with less education were slim to none. Her own boys fledged from the nest, she was appointed in 1896 to the staff of the (then) Division of Vegetable Pathology and Physiology, then under the direction of B.T. Galloway, also interim editor of Journal of Mycology. In this position she excelled and eventually was chosen as Mycologist in Charge of Mycological and Pathological Collections in Beltsville, Maryland. In this capacity she published several bulletins of the Division of Plant Industry (Galloway 1928). She also gathered and disseminated multiplicates of over 1400 excess specimens, not as centuries in the usual exsiccati format, but simply packeted, labeled, boxed, and shipped to institutions in all corners of the United States. In one large assemblage she was aided by W.W. Diehl and Edith Cash of the same department.

Connected with many scientific organizations, Mrs. Patterson was a Fellow of AAAS and member of the Botanical Society of America, National Geographic Society, Washington Botanical Society, Biological Society of Washington, American Phytopathological Society, and American Association of University Women (Charles 1929). Flora Wambaugh Patterson died in Brooklyn, New York, near her sons on February 5, 1928.

Traveling to a job in New York City, J.C. Arthur stumbled into an internship at the newly formed Johns Hopkins University in Baltimore, and upon meeting

William G. Farlow, a guest lecturer, spent a semester at Harvard. Positions followed at the University of Wisconsin (1879–1881) and University of Minnesota (1882) before he was appointed to the New York Agriculture Experiment Station at Geneva, New York in 1884. Arthur easily traveled the short distance to Ithaca, site of Cornell University, to earn Cornell's first Doctorate of Science in 1886. His dissertation was a treatise on pear diseases. In 1883 Arthur and two other scientists founded the Botanical Gazette, destined for a long and prestigious run.

In 1887, Arthur moved to Purdue University, the state's land-grant institution in West Lafayette, Indiana, to begin what evolved into his final position, and he married to Emily Stiles Potter of Lafayette in 1901.

Arthur had kept in touch with Edward Willet Dorland Holway (1853–1923) since their days at Iowa State, and in 1894, like so many mycological colleagues, the two began issuing their exsiccati, *Uredinae* Exsiccati et Icones. Arthur furnished the specimens and identifications, while Holway assumed the actual presentation of the specimens, presumably underwriting the costs as well as collecting in Iowa, California, and Mexico (Stevenson 1971). The number of specimens per fascicle was low compared to other compendia (e.g., Ellis & Everhart), totaling only 60 specimens in four fascicles, the last of which appeared in 1902.

Among Arthur's many students at Purdue was Fred J. Seaver, then beginning a long mycological career at the New York Botanical Garden. "The writer's [Seaver's] first intimate knowledge of Dr. Arthur's work was gained during the spring of 1903 while a student in the State University of Iowa, having been delegated by Professor T. H. Macbride to assist Dr. Arthur in his rust work for that season, at Purdue University. The ten weeks spent in Indiana were both profitable and interesting. Although not particularly interested in the rusts, I was much impressed by the methodical manner in which the culture work was conducted and the great care in handling all details connected with his rust herbarium" (Seaver 1928).

One of his more dispassionate biographers relates that George Atkinson's lectures were dull and boring (Thom 1956) but that frequent fieldtrips were exciting and fun. Students worked into the night arranging and studying the fungi collected during the day. Atkinson's course syllabus was a set of mimeographed detailed keys to the fungi covered in lecture (limited to 25 hard-bound copies with instructions that they were not to leave the lab; Fig. 33), often annotated with personal taxonomic comments. Although

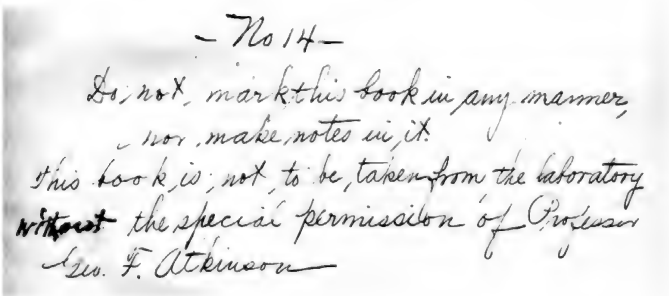
– No 14 –
Do not mark this book in any manner,
nor make notes in it.
This book is not to be taken from the laboratory
without the special permission of Professor
Geo. F. Atkinson

Fig. 33. George F. Atkinson
[Inscription from laboratory syllabus in Atkinson's hand. Ined.]

carefully compiled, it was difficult to determine the taxonomic arrangement of the fungi.

Adding to the attraction of field trips was Atkinson's growing attention to fleshy fungi, commencing about 1900. It must have coincided with his discovery of photography as a means of representing organisms accurately and relatively quickly. The equipment was delicate, cumbersome, complicated to assemble and required lengthy (often a minute or more) exposure (Fig. 34). The final images were produced on thin glass sheets, easily scarred or broken, and faithfully capturing fingerprints when carelessly handled. He introduced such photos as early as 1897 (Atkinson 1897). Encouragement must have come from an unexpected source—C.G. Lloyd, who introduced photographs in his writings as early as 1898 (Lloyd 1898), and Charles McIlvaine was to include photographs in his magnum opus in 1900.

Fig. 34. George F. Atkinson with bellows camera and mushroom subject
[Cornell Plant Pathology Herbarium]

In addition to considering himself mycologically educated enough to summarise some fungal groups (notably polypores, phalloids, and puffballs), C.G. Lloyd also had the hubris to criticize two aspects of the profession: [1] the excess of species being proposed (Lloyd maintaining that there was a limited number of species of fungi and the same organism was being described repetitively) and [2] despite the nomenclatural code's rules for citing originating or transferring authorities, presentation of author names constituted blatant self-advertising and must be eliminated. But instead of merely adhering to his own biases, Lloyd used his pen to chide those who did not conform to his dicta. Not subject to the review process or journal regulations, he used his own self-funded publications for his criticisms. Two devices were conjured for this purpose: [1] "Dr. McGinty" (obviously a pseudonym), who took taxonomists to task but described fictitious species of his own (bringing a problem to the accepted nomenclature regulations), and [2] a small Buddhistic effigy dubbed "Tso Kay," who signaled an attack on "Kuntzeism" (referring to deceased taxonomist Otto Kuntze, who zealously appended his own name after each proposed binomial) and "self-advertising." Transgressors were named, and the offending publication cited. Nevertheless, Lloyd's own taxonomic proposals were legion and filled 290 pages (Stevenson & Cash 1936).

In "The Myths of Mycology," published in 1917, Lloyd wrote, "the mistakes, blunders, and personal foibles of mycological writers have been my chief source of pleasure. I have never failed to express myself plainly, and have spared neither friend nor antagonist. I have always tried to be good-natured in my comments, and as a general thing the parties affected are taking it more as a joke on themselves and an idiosyncrasy of myself. . .. Nor am I deceiving myself into the belief that I will accomplish what I am apparently trying to bring about, the abolition of personal advertisements in mycology" (Fitzpatrick 1927). Not all recipients, however, took them as light. Some, notably Lee Oras Overholts and George F. Atkinson, were wounded. In Overholts' case, Lloyd's comments caused an unfortunate end to the exploration of "split genera" of polypores and return to *Polyporus* as a large and unwieldy assemblage. Atkinson was merely offended, and his self-confidence shaken. He despised Lloyd, but the reverse was not true (Hesler, pers. comm.).

Lloyd established "headquarters" in London, Paris, and Uppsala—also sporadically in Berlin—and knew and was known to many of the active workers of Europe. Their opinions of Lloyd were not recorded, but in far-off New Zealand, frequent correspondent G.H. Cunningham (1892–1962) left

some acerbic comments as marginal notes in his copies of Lloyd publications (S.R. Pennycook, 2019 pers. comm.).

His writings went on unabated until shortly before his death in Cincinnati on 11 November 1926 (age 67) (Fitzpatrick 1927). He had amassed a large herbarium—specimens were received in trade for his writings—and a large library at his home in Cincinnati. Hesler (1975) related the following story: "Shortly after coming to Tennessee [1919], I took occasion to ship a few polypores and related things to [Lloyd]. He responded promptly, and asked for more, which I continued to send for some time. One hot September day, I had stopped overnight in Cincinnati, and went to see Mr. Lloyd at his herbarium. I found the place, stepped to the front door and rang the bell. I saw an older man sitting very close to, but with his back to the open door. He was attired in only blue-jeans and an undershirt, and no shoes. I continued to ring, but he seemed to pay no attention. Finally, the housekeeper answered with a 'ye-e-e-ess?' I said a wished to see Mr. Lloyd. She replied: 'Right here.' And pointed. Finally, I gave her my name, whereupon he wheeled around, greeted me heartily and then took me (he bare-footed) all over the herbarium. I asked what he intended to do with his enormous collection. He said: 'Some good institution will get it.'" That institution turned out to be the Smithsonian Institution and his collections reside at Beltsville, Maryland.

If mycology at the turn of the 20th century had been a court, Lloyd would have been the court jester.

Letter from Father A.B. Langlois (1832–1900 (Fig. 35), in far-off Louisiana, to Lamson-Scribner (1893): "In 1884, through the kindness of Mr. Lehnert, of Washington, I began the study of mosses, liverworts and lichens, and in the latter part of 1885, at the suggestion of Mr. Scribner, I began the study of fungi. I soon acquired a deep interest in these plants, and have been greatly aided in their study by Prof. Ellis, of New Jersey. The mycological flora of Louisiana being so rich and at the same time so poorly known, I have for the past three years given almost my entire attention to it. Every day I make new discoveries, and I am yet far from having exhausted this intensely interesting part of the Louisiana flora... Mr. Langlois has now an herbarium containing some 5000 species of North American plants, including 1214 species of Phanerogams and vascular cryptogams of his State. So far as his State is concerned, this work has been done single-handed. About a year ago [~1892?], Langlois published a catalogue of Louisiana plants which embraced the fungi he had found, now numbering 1200 species. Langlois' collections

Fig. 35. Father A.B. Langlois
[Courtesy Dr. Meredith Blackwell]

are widely distributed in the herbaria of this country and in France, and his specimens are highly valued by all who possess them."

Edward Angus Burt (1859–1939; Fig. 36) is best-known for his series on the *Thelephoraceae,* but his background is also elucidating. Born in Athens, Pennsylvania, a small settlement on the Susquehanna River, his early years are unrecorded. One position held (1880–1885, credentials unknown) was at Albany [New York] State Normal College, where he knew Peck, and where C.L. Shear was one of his students. After this practical experience, Burt was awarded a Harvard B.A. in 1893 at age 34, followed by an M.A. in 1894. There he was a product of William G. Farlow and Farlow's assistant and successor,

Roland Thaxter. Burt's next appointment was at Middlebury College in Vermont (1895–1913). Finally, in 1913, he was employed as Mycologist and Librarian at the Missouri Botanical Garden in St. Louis. He held a concurrent position at the Henry Shaw School of Botany at Washington University, also in St. Louis. Coincidentally, C.L. Shear was again a Burt student. When the Farlow watercolor illustrations of mushrooms by Bridgham and Krieger were being compiled into book form (see below), Burt wrote descriptions for each species, including some nomenclatural and/or experiential annotations. It was also during this period that he published the series on *Thelephoraceae* as the family was understood at that time. While its content was as detailed nomenclaturally as the times would permit, descriptions and illustrations

Fig. 36. Edward Angus Burt
[Mycol. Notes (Lloyd) no. 47. 1917]

were not so, and the series met with mixed reviews (Lloyd 1917). He died in Ballston Spa, New York, in 1939 at age 80.

In July 1887, Henry Ravenel suffered a serious of small strokes, but death was caused by failure of vital organs—in short, by old age. His herbarium was sold piecemeal—a substantial portion of the cryptogams to the British Museum for $600. Long after his death, a large part of his phanerogams was sold to George Washington Vanderbilt (1862–1914) for his planned Biltmore estate and ultimately were ruined by a flood. Another part went to Converse College, SC.

Mycology in the last quarter of the 19th century is a piecemeal story. Several young men were in various stages of their careers, most as teachers in high-school situations. Their careers can be traced, and their interactions considered, but information on their personal lives and personalities depend largely on obituaries, some of which are eulogies and others dry and skeletal.

Lucien Underwood's days as an Illinois school principal began an all-too-common tour of teaching jobs—1878–1879 back at Cazenovia, 1879–1880 a professor of Natural Sciences at Hedding College, and 1880–1893 at Illinois Wesleyan University (in 1881 marrying Marie A. Spurr, who would accompany him on all subsequent career moves). In 1883 he became Instructor at Syracuse (New York), a less peripatetic position lasting until 1890 during which Underwood introduced the "new" method of teaching biology with using microscopes and living plants, introduced at Harvard some years previously.

One of William Kellerman's major contributions to mycology per se came with the start of the Journal of Mycology with J.B. Ellis and B.M. Everhart as co-editors. With volume two, however, Kellerman was sole editor. Volumes 1–5 (1885–1889) were decidedly mycological in content but included reviews of literature and mycological news. Financial difficulties grew, however, and volumes 6 & 7 (1891–1892) were issued by the USDA with the 26-year-old Beverly Thomas Galloway (1863–1935) as editor. Content was almost exclusively phytopathological, in keeping with Galloway's interest and Galloway's position as Chief of the brand-new USDA Division of Vegetable Pathology and Physiology. After a ten-year publication hiatus ensued, in 1902 Kellerman (by then at Ohio State University) took back the Journal of

Mycology and maintained it until his death in 1908. The journal, he testily stated, separated mycology from phytopathology, emphasizing the former. In doing so, it created a focal point for American mycologists who could read each other's research and keep track of positions and locations. The journal fulfilled a necessary nucleus around which the discipline could gather, but with Kellerman's death in 1908, it ceased, leaving North American mycology without such a publication for many years.

Although described here in only a few words, the country shivered through an economic crisis in the mid-1890s. Blamed by some on failed investments in far-off Argentina, a Euro-American wave of stock sales into currency backed by gold & silver spurred failures of 500 banks with insufficient gold reserves, over 15,000 private businesses, hundreds of over-extended farms, and the bankruptcy of the country's three largest railroads. Soup kitchens emerged in big cities, presaging the Great Depression some 30 years distant. Based on shrinking tax revenue throughout the country, administrations from municipal to federal cut back on employees and salaries. Reduction in expenditures (including salaries) rippled through college and university budgets, while tuition revenue decreased. One small corner of this trauma affected individual government employees whether at the USDA, the newly founded New York Botanical Garden, or the Land-Grant universities across the agrarian states. Although not everyone was put on "reduced rations," anxiety over the future of capitalism and democracy was rampant as unemployment reached 25% in Pennsylvania, 35% in New York, and 45% in Michigan (compared with <10% nationwide unemployment during the 2008–2011 recession). Until some order was restored in 1897–1898, mycological progress, like everything else, stood still and many of the characters introduced here must have had life-altering circumstances seemingly unrelated to their mycological activities.

After his wife's death, J.B. Ellis redoubled his taxonomic research and in 1892 again teamed with Everhart, this time to publish The North American *Pyrenomycetes*. As usual, it would appear that Everhart's philanthropy made publication possible. It was to be Ellis's last major mycological contribution. Everhart passed away 22 September 1904 in West Chester, PA, with Ellis dying a few months thereafter at home in Newfield on 30 March 1905.

Ellis, for all his productivity, was a simple, unassuming person from early age onward. Unlike some other mycological associates like Farlow at Harvard

or Atkinson at Cornell, Ellis had no students to mentor and no immediate colleagues with whom to share opinions. Two quotes from others sum him up. Written 15 years before Ellis's death: "His fellow-botanists feel his influence and recognize the value of his work but wonder why they never see his kindly face at any of the botanical meetings of the country. It is simply because his health at all times precarious, demands constant quietude coupled with strict simplicity and regularity in his daily life. A thorough scholar and quite a linguist, he is perfectly familiar with Latin, Greek, German, and French and has also a good practical knowledge of Polish, Swedish, Italian, and Spanish" (Anderson 1890).

From Curtis Gates Lloyd (1915), not easily given to kind words about fellow mycologists: "He [Ellis] was exceedingly timid and shrinking, but possessed of a charming personality, and by his lovable disposition endeared himself to all who knew him.

"While I was aware of many mistakes that he made, I never, during his lifetime, mentioned one of them in print. So earnest and honest was he in his work, and possessed of such a lovable disposition, that it was impossible for me to say a word that might have hurt his feelings in any way. I do not know of any other person towards whom I have felt exactly as I did towards Mr. Ellis, but consideration for his sensitive disposition and the high regard in which I held him personally, prompted me thus to make of him an exception" (Lloyd 1915).

Home-grown mycology

In the years from 1875 until shortly before his death, Farlow assiduously gathered the tools of his discipline, cryptogamic botany: reference specimens, reference library, indices to the field. The first were obtained by purchase of numerous exsiccati, both domestic and foreign. These were kept intact but indexed, so specimens could be retrieved easily. The second meant purchase of domestic and foreign books and journals resulting in the largest mycological library in North America. Third, several major indices were developed, most of them unpublished (Setchell 1927). In one (Farlow & Seymour 1891), Farlow wrote: "...believing that an approximately complete list of our parasitic species and their hosts would aid materially in the advance toward a more accurate study of our mycological flora and would tend to lessen the amount of indiscriminate species making which has already become a serious evil, the present index, the result of work extending over several years, has been prepared for publication." Although written for parasitic fungi, the words

echo those written over the years by Lloyd for some of the same reasons. In response to a swelling body of mycological literature, Lindau and Sydow (1908) began their multi-volume bibliographic compilation, Thesaurus litteraturae mycologicae et lichenologicae.

Married late (1900 at age 56), there were dinners at the Farlow home for students and staff and the establishment of a summer home at Chocorua, New Hampshire, on a lakeshore that he made famous for its wealth of fleshy fungi. Setchell (1927) alluded to Farlow's quiet financial support for impecunious students, and Stevenson (1971) reported that Farlow may have helped Ellis to launch his exsiccati, North American Fungi. The cover of Century III indicates so.

At Farlow's death (1919), his entire gathering of books and specimens made its official way to Harvard where it formed the bulk of what became known as the Farlow Herbarium and Library, the cryptogamic analog to the Gray Herbarium and Library. Farlow's roster of students was Malthusian: leading lights included Blakeslee, Duggar, Pierce, Oakes Ames, Faull, Schenk, Fink, Riddle, Burt, Jackson, and Thaxter, each becoming a leading contributor but mostly after the time treated here.

In 1884 and again in 1885, Lucien Underwood had traveled to Harvard to study with Asa Gray. This experience doubtlessly opened his eyes to the greater transatlantic connections possible for a botanist. An AAAS meeting in Ann Arbor, Michigan, presented an introduction to J.C. Arthur, already becoming a recognized authority in the rust fungi. In the summer, Underwood collected plants in Tennessee, Georgia, and Virginia for the Smithsonian Institution, and in 1886, he was promoted to professor at Syracuse. Throughout this period, his interests were drawn increasingly to the fungi, and in 1889 Underwood and his student Orator Fuller Cook issued their exsiccati, A Century of Illustrative Fungi with Generic Synopses of the *Basidiomycetes* and *Myxomycetes* (Stevenson 1971). The long introduction (27 pp) treated fungal classification in general and then provided family and generic keys for the covered groups. Fungi were arranged taxonomically: 1–59 *Basidiomycetes,* 60–85 *Ascomycetes,* 86–88 *Fungi Imperfecti,* 89–93 *Phycomycetes,* and 94–100 *Myxomycetes* (Stevenson 1971).

But Underwood's travels were not yet over. In 1890, he was Professor at De Pauw University, Greencastle, Indiana, but the winter of 1891–1892 was spent in Florida studying diseases of orange for the USDA, and he visited

Cuba in 1892. His growing reputation prompted election to the committee on nomenclature for the Rochester botanical meeting in 1891 and as a delegate to the Genoa Botanical Congress in 1895. This trip had the "... advantage of the opportunity to examine the famous herbaria and become acquainted with the European botanical leaders in his line of study, such as Prantl, Strassburger, Ascherson, Magnus, Ward, Chodat, Saccardo, De-Toni, Baillon, and others. The interest thus aroused led him repeatedly to visit England and the Continent, in all making eight trips for the purpose of comparison and study at various botanical centers" (Curtis 1908).

As though in direct contradiction to Atkinson's and Lloyd's photographic depictions, in 1889, Farlow hired John Bridgham to illustrate fresh fungi. His watercolors were careful, attentive to detail under Farlow's eye, and quite lovely. His fee was $5.50 per diem (computed at about 75 cents per hour for a full day's work). He continued for 12 years (1901) before retiring. Bridgham was replaced by the already recognized L.C.C. Krieger, who moved to Cambridge for this singular purpose. Krieger continued in Farlow's employ for a decade (1912), his aquarelles every bit as fine as those of his predecessor. During his tenure with Farlow, Krieger developed interest in presenting fungi, including slime molds, to the public, publishing in National Geographic Magazine (Krieger 1920) and a handbook for the public (Krieger 1935; financially supported by Dr. Howard A. Kelly, his long-time patron). In the magazine and handbook, Krieger's watercolor illustrations were supplemented by photographic images. The work of both Bridgham and Krieger was gathered posthumously, paired with descriptions by Farlow's former student E.A. Burt, and published as Icones Farlowianae (1929, with notes by Farlow written in 1892; Pfister 1975).

The brief (April–December 1898) Spanish-American War ended with the Treaty of Paris, which exchanged Cuba, Puerto Rico, the Philippines, and Guam to the United States in return for $20 million. During the three and a half years before Cuban independence in May 1902, Cuba was a U.S. protectorate.

F.S. Earle was apparently attracted to tropical and/or subtropical climates and their mycological possibilities, for in 1904, he accepted directorship of Estacíon Agrónomica, Santiago de Vegas, Cuba (by then under the Cuban government). The station soon closed, receiving inadequate governmental support. For several years, Earle was agriculturist to the Cuban-American

Sugar Co. as well as President of the Cuba Fruit Exchange, also investing in some private fruit-growing enterprises with varying success (Chardon 1929). His worthy reputation was rewarded as Associate Editor of Mycologia and (1908) President of the Botanical Society of America. In 1918, with World War I directing political affairs in the United States, the USDA appointed Earle as specialist in sugar-cane culture and commissioned him to visit Puerto Rico with the purpose of studying a very severe disease of sugar cane. Earle's genetic immunity experiments restored sugar cane production, and his reputation grew accordingly. Over the following years, he moved from job to job, eventually associating with the Tropical Plant Research Foundation until a few months before his death in Herradura, Cuba, on 31 January 1929 (Chardon 1929).

Were it not for Earle's contribution on agarics, he would not be considered for this sketch, for his entire career was centered on phytopathology, especially diseases of sugar cane. He was surely a leader in carving a career in the south and in his case, the Greater Antilles.

As the 20th century unfolded, an important document was issued from Washington which, while surely not aimed at mycology, nevertheless encouraged mycological discovery. Theodore Roosevelt signed a letter of transmittal "To the Senate and House of Representatives" dated 19 December 1901 (Anonymous 1902b). According to the book-long report, there had been an "uprising of the American people" over "an interest in practical forestry, notable and commendable," having been preceded by establishment of forest preserves in the western states. "A movement has grown to establish a forest preserve in the southern Appalachians. The states which include this region do not own appreciable land and do not have the revenues to purchase it. It is therefore the federal government's responsibility to purchase the forested lands needed as a preserve." The movement for "preservation by the Government of the hardwood forests on the slopes of the Southern Appalachian Mountains" led to the National Forest system up and down the Appalachian chain from New England to Florida, large patches of which were to become National Parks.

Europe, of course, had not been still during the latter quarter of the 19th century. M.C. Cooke (1893) wrote a textbook in which he outlined his classification scheme. The giant score-keeper of mycology was Pier Andrea Saccardo (1843–1920), who only meant to track the *Pyrenomycetes* in Sylloge

Fungorum (1882) but wound up with 25 monumental volumes extending past his death to 1931 (Petersen & Hawksworth 2016). In original research the French became pivotal: Lucien Quélet (1886), and especially Narcisse Patouillard (1887, 1900). Patouillard's incessant use of the microscope was establishing cracks in the Friesian edifice of classification, and the Saccardo scheme, while practical, was totally artificial. As Patouillard's work became better known (French works took some time to become "discovered" by non-Francophones), anatomical observations made fungal grouping different than that based solely on basidiomatal macromorphology (Petersen 1971). Meanwhile in Germany, a father and son team, Paul (father, 1851–1925) and Hans (son, 1879–1946) Sydow, endeavored to start a new mycological journal. Although, by now, some mycological journals already existed (i.e. Bulletin de la Societé Mycologique de France; Journal of Mycology), none was German or Germanic. In 1903, the team launched Annales Mycologici, which was to run through World War II.

Underwood's trans-Atlantic travels and time at Harvard convinced him that a flora of North America, long dreamed by Gray and Torrey, should be resuscitated. "[E]arly in 1893 he wrote a letter to Professor Britton [New York Botanical Garden] proposing the formation of a body to organize a general descriptive work on the flora of North America. This resulted in the creation of a standing board of editors of the Systematic Botany of North America, which was subsequently transferred to Underwood and Britton under the new title, North American Flora, to be published by The New York Botanical Garden" (Curtis 1908). Nathaniel Lord Britton of Columbia University had been instrumental in organizing a movement which resulted in the 1891 establishment of The New York Botanical Garden (Britton's Botanical Empire: The New York Botanical Garden and American Botany. 1889–1920).

Then at De Pauw University, institutional financial difficulties forced Underwood again to change jobs. The details of his migration are not known, but 1895 found Underwood at the Alabama Polytechnic Institution (later to become Auburn University). George Atkinson, who had been on the Alabama faculty during 1888–1892 before returning to his alma mater (Cornell), was followed by a zoologist on staff. Underwood came to Alabama for 1895 to be followed by F.S. Earle from 1896 to 1902. All three mycologists were well-reputed: Atkinson and Underwood moved to more prestigious universities while Earle moved to the Caribbean as a leading phytopathologist.

In the spate of mushroom books emerging toward the end of the century came two dealing with small regions, both largely overlooked in subsequent years. The first on the Miami Valley of Ohio penned by A.P. Morgan came in several parts (Morgan 1883–1888), while the second (Herbst 1899) covered the Lehigh Valley of Pennsylvania. Some words have been devoted above to Morgan (by this time on the farm with his wife), but William Herbst (1833–1906) is also deserving, "being the foremost physician of [Berks] county until his death. He served for thirteen years as physician at the almshouse, [and] filled the chair of botany at Muhlenberg College." "Lutheran by religion, Democrat by politics, member of the Masonic fraternity" (Roberts & al. 1914). Like so many others, Herbst acknowledged "Professor Peck, [who] through his annual reports to the State Museum, and correspondence, was my best teacher for the last twenty years" (Herbst 1899).

Herbst additionally noted, "C.G. Lloyd, of Cincinnati, had the kindness to visit me for a number of years, giving me a fresh stimulus to this fascinating study by his assistance in working out some interesting species" (Herbst 1899). In return, Lloyd gave Herbst's book a complimentary review: "His work we consider the most helpful single volume that has ever been issued on American Agarics, because it considers and describes most of the common plants (those met by everyone). All who are making a study of fungus should procure it" (Lloyd 1900).

Employed for short periods as a railroad civil engineer, Charles McIlvaine seemed never to require steady employment and perhaps came to exhibit a sense of entitlement as a person who was rarely wrong and—to a large extent—master of his universe. During the post-War years he married Sarah G. McIlvain (no relation). After an 1873–1874 tour of Europe, he began penning contributions to American magazines: whimsical stories, verses, and occasional scientific op-ed pieces, often written under the nom de plume, Tobe Hodge.

By his words, he lived in West Virginia in 1880–1883. It was during a horseback ride in this period that he was abruptly made cognizant of the mushrooms growing all about him. Searching for written material about such things, he was drawn to an article in Popular Science Monthly (Palmer 1877). The article offered a wordy mushroom primer, but also referred to several British books. Whether McIlvaine searched out any of them is unknown, but he set out to learn more, apparently not for elucidation of the organisms themselves but with which to experiment with edibility.

The result was such experimentation on over 800 taxa with notes on many more (McIlvaine 1900), earning him the sobriquet, "Iron Guts McIlvaine." McIlvaine gave generous thanks to C.H. Peck, who had been New York State Botanist for years and was the unrivaled expert on eastern North American mushrooms. But the same hubris which allowed McIlvaine to "experiment" with edibility also gave him license to identify and to name many of the forms in the book. This could easily be multiplied by the ignorance of the reader, which led to critical reviews by full-time mycologists.

One of the less enjoyable tasks of the New York State Botanist was to compile and submit an annual report on his activities. This Peck did assiduously for all the years of his tenure. Once out of his hands, his report was joined to others – zoologist, geologist, etc. – in a year-end report by the State Museum. In 1890, Peck (1890) separately reported on a gift of mushroom illustrations by Mary Elizabeth Banning (1842–1901), among the very best ever produced in the United States (Bridgham and Krieger were yet to come some years hence). Banning's paintings remain in the New York State Museum.

Import-export mycology

In spite of his job as director of all research at the Cornell University Agriculture Station at nearby Geneva, New York (Humphrey 1961), Atkinson's passion for taxonomy of fleshy fungi prompted a trip to Sweden in 1903 in search of the Friesian identification of mushroom species. There he was welcomed by Lars Romell (1854–1927), almost his exact contemporary, who shepherded him in the field and furnished names for the collections. Soon thereafter, frequent Swedish stops were included by C.G. Lloyd, by then a mycological rival.

It must be remembered that for such international travel, months were required for securing reservations in agreement with timetables, for stateroom and venue accommodations, baggage disposition, and ground transportation, all by time-consuming international post. Trans-Atlantic journeys required at least two weeks of steamship travel in both directions as well as rail transportation from embarkation port to and from the desired destination.

Mycology, like almost all other human activities, flourishes not only through participants – researchers, students, learned amateurs – but by the financial backing which permits such activities. Often, when some form of government does not provide needed funds, the philanthropy of individuals comes to the rescue. Such was the contribution of Howard Atwood Kelly

(1858–1943; Fig. 37), a well-reputed medical practitioner in Baltimore, Maryland. Having amassed more than a comfortable fortune by mid-life, Kelly could indulge his avocational interests in natural history. Time constraints did not permit personal research, but vicarious satisfaction could come by gathering the tools of the trade, in this case mycology. He sought and purchased a magnificent botanical library heavy in mycology and lichenology, including manuscripts and letters, original images and reproductions, herbaria, and

Fig. 37. Dr. Howard Atwood Kelly
[Mycologia 35(1). 1843]

Fig. 38. Lewis Charles Christopher Krieger
[Mycologia 33(3). 1941]

exsiccati. But such acquisition still took time, both in the execution and in the arrangement and indexing of individual items. For the decade between World War I and the Great Depression (1918–1928), Kelly employed Lewis Charles Christopher Krieger (1873–1940; Fig. 38) for just this purpose. As mentioned earlier, Krieger was a superb illustrator who had worked for William Farlow at Harvard during 1902–1912, and during his time with Kelly, Krieger also contributed over 300 original watercolors to the doctor's cache. The index alone of Kelly's collection was book-length and published by Krieger (1924).

In 1928, Kelly donated his enormous collection of printed material, archival holdings, herbarium, and mycological images to the Herbarium of the University of Michigan, where they remain available to the mycological community. The event put Krieger out of work although he did remain honorary curator of the Kelly collection.

Through several posts in and out of government, all after the period sketched here, Krieger continued using his artistic skills, but lest he be considered solely an artistic amanuensis, he also became an expert on mushrooms themselves and the history and technique of his illustrative art (Krieger 1922, 1926, 1936, 1940), publishing several (some book-long) contributions. In 1929 (a dozen years after Peck's tenure), he became Mycologist of the State of New York and published (tardily) a mushroom handbook (Krieger 1935). Krieger died shortly after his wife. Of him, the following: "A figure unique in the annals of American mycology passed from the scene of his earthly labors July 31, 1940. L.C.C. Krieger was the creator of the finest series of watercolor paintings of the fleshy fungi yet produced in America." Further, "such perfection of illustration has never been reached by anyone else in this country and in Europe only by Boudier. There may never be another as competent as he" (Lloyd 1920). "Not only do Krieger's plates approach perfection artistically, but they are technically correct as well to the most minute detail, a rare but much to be desired combination" (Stevenson 1941). Meanwhile, Kelley took his place as mycological philanthropist alongside Farlow (to Harvard) and Everhart (to J.B. Ellis).

Reduced duties in the Cornell Botany Department gave Atkinson the freedom to write on botanical education, including several books: Biology of Ferns (1894), Elementary Botany (1898), First Studies in Plant Life (1901), Lessons in Botany (1901), A College Textbook of Botany (1905), and Botany for High Schools (1910)—a prodigious output, when added to his Studies of American Fungi, first issued as bulletins 138 and 168 of the Cornell Agricultural Experiment Station, then as two book editions (1900, 1903) with numerous photos).

In 1911, Robert Almer Harper became Torrey Professor of Botany at Columbia University, with a close association with The New York Botanical Garden (NYBG). How different Manhattan must have seemed when compared with his previous life in rural settings. Over his Columbia career "he spent one day per week at [NYBG] for many years. During this period, he was interested in

corn genetics: hybrids between sweet corn, flint, dent, flour, and pop-corn" (Stout 1945), leading him to doubt the prevailing Mendelian genetics of that day. He conducted his research at the NYBG experimental garden and a farm in New Jersey bought by him & wife. Harper's NYBG involvement included membership on the Board of Managers for 31 years.

Even at urban Columbia, he led numerous field trips for Torrey Club members and Columbia students. "He bought a Panhard automobile in which he carried students to the Pine Barrens of New Jersey, to Cold Springs Harbor, Long Island [and other seaside destinations]" (Anonymous 1942). [Panhard was a French brand of luxury cars, never overly popular but innovative; for some years, the steering wheel was positioned in the middle of the dashboard—between the passengers but making it easier to drive in both left- and right-hand countries)].

Robert at Columbia had a brother, Edward T. Harper (1857–1921; Murrill 1921), a theologian. A graduate of Oberlin College (1881), Chicago Theological Seminary (1886) and a D.D. from Leipzig (1891), Edward became a professor of Semitics and Comparative Religions at his alma mater (1892–1911). But in addition to his calling in theology, his strong avocation was botany, especially fungi (probably influenced by Robert). He published no fewer than six papers on the fungi of the Great Lakes area and his collections formed the basis for the mycological herbarium at the Field Museum. Edward's photographic illustrations were especially admired, and Krieger (1922) used them as an example of the "heliogravure" process.

During his closing days, Andrew Morgan studied and published on a variety of mushroom groups, often monographing his current interest. He died in 1907, on the farm in Preston, Ohio. Lloyd (1908), in a eulogy on Morgan, reported, "[Morgan] pursued the study of mycology solely as a mental recreation." "... and it was he who first gave me an introduction to the study of mycology." Considering Lloyd's blizzard of contributions, Morgan might have been reluctant to claim his mentorship of the acerbic Cincinnati writer-mycologist.

Some years after being passed over for a position at Ohio State University, in 1901 Kellerman was appointed to the faculty there and soon had the Journal of Mycology running again. His publishing days did not stop there, however, and in 1903 he started the Ohio Mycological Bulletin, a pamphlet-sized organ aimed more at an amateur audience. It continued for

at least 41 issues. These activities could still be carried on despite his gradual hearing loss (Griggs & al. 1908).

Also in 1903, Kellerman, like several of his contemporaries, discovered the tropics and its natural riches. After a preliminary foray to Guatemala, he organized subsequent class trips with students, reveling in the experience and its surroundings. The Ohio State administration approved of his plan and in 1908, he took the class back to Guatemala. But during preparations just prior to their return, Kellerman was stricken with malaria and after a few days of incapacitation, died on 8 March 1908 in Zacapa, Guatemala, where he was buried. With him went the Journal of Mycology and the Ohio Mycological Bulletin. The former was to see a considerable hiatus.

Kellerman's life was celebrated by many, for his cheerful energy and published output made his mycological name a common, household commodity.

Quite probably based on his relationship with N.L. Britton (Merrill 1938, Mickulas 2007), in 1896, Lucien Underwood was appointed to the faculty at Columbia University in New York City. There he was within a half-day's buggy ride to the newly founded New York Botanical Garden. Looking back over his experiential shoulder, he published with F.S. Earle a list of Alabama fungi (Underwood & Earle 1897). In 1899, Underwood's "amateur's guide to mycology", Moulds Mildews and Mushrooms was published (Underwood 1899). Hardly an amateur guide, the book provided genus-by-genus summaries and a fairly extensive history of mycology, mostly in Europe. Even a list of collectors who had sent specimens to Curtis was inserted (p. 161). A careful inspection of the state-by-state list of literature would reveal numerous references to places where Underwood himself had collected or resided: Alabama, California, Connecticut (several summers in the northwestern corner), Florida, Indiana, central New York. Together with an honorary LL.D. from Syracuse, the book would crown a long career in the fungi (Barnhart 1908, Howe 1908). Underwood died at home in Redding, Connecticut, in November 1907.

If one could use the term "retirement" for a man of means and no regular employment, Charles McIlvaine retired to Cambridge, Maryland, where he died on August 4, 1909, a widower without heirs. He was active in the Chautauqua movement, lecturing often on his favorite topic, but also on more scientific planes. His most significant production was popularly nicknamed

"The Mushroom Bible," (Bowser 1972) and had met with mixed reviews but also commanded a "cult following" which existed well into the 20th century.

Peck published his annual reports from 1868 until his retirement in 1915 (Petersen 1980b). Established as the country's mushroom expert, Peck received specimens from all over the states. More or less in return, he contributed specimens to at least 16 centuries of von Thümen's exsiccati, Mycotheca Universalis. None of the specimens, however, represented types (Stevenson 1971)

The annual reports were interspersed by occasional papers on extralimital taxa in either the Buffalo Natural Science Society Bulletin or the Bulletin of the Torrey Botanical Club. One of his biographers (Burnham 1919) estimated Peck's output at 2700 new taxa, most of them hymenomycetes. Two indices summarize his output: one by Peck (Bull. N.Y. State Mus. 131: 51–190), the other by Gilbertson (1962).

In 1915, Peck suffered a series of small but debilitating strokes, necessitating his retirement from active duty; in 1917, he died of a massive stroke in Menands, near his family home.

Atkinson's growing reputation in research and education led to his election as the first President of the Botanical Society of America in 1907. He might have served equally in the mycological community had an organization of mycologists existed at the time, but that was some years away.

Atkinson made the laborious trip to the International Botanical Congress in Vienna in 1905, only to have mycological topics such as starting date for fungal names and the type method postponed until the scheduled Brussels Congress in 1910. Together with William Farlow and J.C. Arthur, Atkinson attended the Brussels Congress, where botanical (and therefore mycological) nomenclature was a significant topic. One can imagine lively conversations among the trio, perhaps including the use of photographic images versus watercolor paintings.

When Atkinson, Farlow, and Arthur "sailed" to Europe for the Brussels Congress they would have been passengers on a steamship with steel hull and rigged with a screw—a propeller under the posterior of the hull. Although some cargo might have been loaded, above-deck passengers would have had staterooms (often fitted with a porthole), while below–deck "accommodations" were dubbed "steerage" for their proximity to the engine room. Masts and sails would have been jettisoned decades earlier. Fuel was

coal (probably bituminous), producing billows of ashen smoke for anyone downwind from the funnels. Diesel engines in large ships were decades away.

In Brussels, mycological subjects would be discussed and committee reports circulated prior to the Congress proper. Although not on the "official commission" of the AAAS Botanical Club, Atkinson was a strong proponent of the resultant American Code of Botanical Nomenclature (Anonymous 1907) which enshrined these principles. Duly, Atkinson shepherded many of the principles of the American Code into the International Code. At Brussels, he was not only a member of the nomenclature commission but represented The University of Chicago, Cornell University, University of Nebraska, AAAS, University of Vermont, and the American Phytopathological Society. At the nomenclature sessions he introduced several motions already in the American Code, of which all but one was accepted (the last being postponed in the rush to adjourn) (Wildeman 1910).

The closing chapter

Throughout his career in phytopathology, C.L. Shear persisted in studying the fungal pathogens themselves, more than just the diseases they caused. His more outstanding mycological contributions were The Genera of Fungi with F.E. Clements (1931) and, with B.O. Dodge (1927), "Life histories and heterothallism of the red bread-mold fungi of the *Monilia sitophila* group" (Jour. Agric. Res. 34: 1019–1042). This latter paper launched a career for Dodge, put *Neurospora* on the genetic map, and got Dodge an acknowledgement in Edward Lawrie Tatum's Nobel Lecture. Shear's voluminous report on cranberry diseases served as his thesis for his 1907 Ph.D. from Washington University (St. Louis), where his faculty advisor was E.A. Burt.

Also a student of mycological nomenclature, Shear was a delegate to the international botanical congresses held in Vienna (1905), Brussels (1910), Ithaca (1926), and Cambridge (1930), as well as to the 1950 Stockholm Congress, which he did not attend because of ill health.

Retiring in 1935, Shear maintained his Washington, D.C., office while spending winters in Florida. His Mycological Notes were published during 1937–1940 (Cash 1954). After his wife died in 1950, Shear moved to live with his daughter in Monroe, Louisiana, where he died in 1956 (Stevenson 1957).

Shear's career balanced phytopathology and mycology, and his major mycological contributions were made after the time period of this sketch.

It would be easy to label J.C. Arthur a phytopathologist and thus peripheral to this sketch, but his work on rust fungi, starting with their complex life cycles, included "sowing" rust spores on possible alternate, greenhouse-grown host plants. His own report (Arthur 1921) listed some 2300 collections involving 3750 pairings (Mains 1942, Hesler 1975) Thus, fungal genetics and physiology were intricately involved.

Among his well over 200 published reports, a few are truly stellar. Early on, Arthur (1905) used analysis of spore stages in the rust life cycle as the basis for a new classification (Petersen 1974). Almost simultaneously, Arthur, together with students and collaborators, started treating the rusts for North American Flora (Arthur 1907). His students over the years included G.B. Bisby, F.D. Fromme, H.S. Jackson, F.D. Kern, E.B. Mains, and C.R. Orton. Well after retirement in 1915, Arthur (1934b) published his Manual of the Rusts for North America, aided by George Cummins.

"He [Arthur] was naturally much concerned with the rules of nomenclature, not only as they applied to his group of rusts, but also as they applied to the host plants. He was active in the Congresses at Vienna (1905), Brussels (1910), and Cambridge (1930). In 1925 a trip was planned specifically to confer with European mycologists who had special interests in the rusts. It was the privilege of the writer to accompany Dr. Arthur on this trip. Visits were made with Klebahn, Sydow, Dietel, Kniep, Lagerheim, Eriksson, Juel, Jørstad, Gäumann, Ramsbottom, Butler, and Wakefield. A paper in Science (Vol. 43, pp. 558–560), entitled "Conversations with European Mycologists," illustrates the value of exchanging opinions with fellow botanists in Germany, Sweden, Norway, Switzerland, and England. It was a strong link in a chain of cosmopolitan activities forged by Dr. Arthur throughout his long life" (Kern 1942).

Finally, Hesler reported on an event that brought Arthur's iconoclastic streak full circle. "After retirement, Arthur became upset when something happened to displease him. In his miff, he engaged a moving-van on a Sunday, and moved the entire rust herbarium to his home in Lafayette. The Purdue community, naturally disturbed, persuaded the President of the University to pay a personal call on Dr. Arthur at his home. After some diplomatic exchanges, Arthur engaged the van to haul it all back to its rightful place the next day" (Hesler 1975; confirmed by Cummins).

J.C. Arthur died on 30 April 1942 in Brook, Indiana. Although mycology lost the worlds' expert on rust fungi, the Arthur Herbarium lives on, and his students (and their students) spread mycological research and pedagogy to this day.

After retirement from Columbia in 1930, R.A. Harper remained active as Professor Emeritus until 1938, when the Harper family (Robert, wife Helen, their son and grandson) moved to Bedford, Virginia, on a former plantation of about 435 acres in the mountains between Lynchburg and Roanoke (Stout 1946). In 1942, the Torrey Botanical Club celebrated his 80th birthday. Harper died on his Bedford farm 12 May 1946.

Hesler wrote: "About 1928, I visited Harper at Columbia. I found him an imposing figure, over six feet high and weighing perhaps 220 pounds. He had an unusually pleasing voice, was distinguished in appearance, and had great personal magnetism" (Hesler 1975). Further: "He had a sense of humor: Harper admired a (then) young physiologist, W.J. Robbins, later Director of The New York Botanical Garden, and took Robbins on a mushroom hunt. Once they gathered *Polyporus sulphureus* which Harper cooked. On tasting, Harper remarked: 'Well, I believe that it is fully equal to a good grade of filter paper cooked the same way'" (Hesler 1975).

It might be asked why Harper is included in a sketch of mycology. At Wisconsin, Harper included fungi with all other botany and his students were well-trained therefore. In his last decades at Columbia, his interests were focused on the heredity and cytology of ascomycetes and myxomycetes, passing his information to his students. He maintained a mycology genealogy at Columbia (which also included Lucien Underwood) and at The New York Botanical Garden, where F.S. Earle spent a short but meaningful period.

By the time of Farlow's death in 1919, Harvard had become the Kew of North America, surely on a par with the other United States mycological centers. The combination of Smithsonian Institution, Library of Congress, and Department of Agriculture could have made Washington a contender had the collections and libraries been centralized, but The Missouri Botanical Garden (opened in 1859) and The New York Botanical Garden (founded in 1891) were vying for recognition.

In his final year of life, with clouds of WW I darkening, Atkinson was honored by election to the National Academy of Science. Funded by a USDA grant to collect *Amanita* and *Clavaria*, he embarked upon a lengthy (albeit truncated) field trip to Florida, Georgia, western Virginia, and North and South Carolina. The man Atkinson had hired as an assistant was abruptly drafted into the army, but Atkinson opined that two women might be able to handle the job, and so it was (Haines 1987). Destinations included Chapel

Hill, a former academic stop in Atkinson's career and now home to William Chambers Coker (1872–1953), whose taxonomy was inferior in Atkinson's eyes (see Haines 1987). Later in the year he traveled to the Pacific Northwest, where he was first ill with "Spanish flu" (an early victim of the 1918–1920 influenza pandemic), and then, no doubt weakened, in Tacoma, Washington, fatally succumbed to pneumonia at age 67. His last photo—of Mt. Rainier—survives in the Cornell Plant Pathology Herbarium.

Atkinson's 1903 European travel coincided with the first powered flight at Kitty Hawk. By the time of his death fifteen years later, biplanes, now a common sight, were about to be put to use in World War I. In fact, during Atkinson's lifetime, Google tells us that Bessemer forged steel from iron, Nobel invented dynamite, Pasteur produced the first vaccines, Bell invented the telephone, Edison introduced the incandescent light bulb, the Brooklyn Bridge was opened in 1883 to horse-drawn and pedestrian traffic, and Henry Ford produced Model T Ford cars on an assembly line (1903). Mycology was keeping pace with civilization.

Estey (1994) reported that Canadian mycology was late to develop. Among the earliest plant collectors were John Macoun (1831–1920; see above), "who collected thousands of fungi from coast to coast in Canada and was the first federally employed botanist to publish on fungi" (Estey 1994). Somewhat later, James Fletcher (1852–1908) migrated from England and was appointed Dominion Entomologist and Botanist in 1884, shortly before the Central Experimental Farm in Ottawa became a reality. He was instrumental in establishing the National Collection of Vascular Plants, the National Herbarium, the National Arboretum and Botanic Garden. He was also an avid field researcher who personally collected thousands of plant specimens. He conducted successful research on effective treatments of various agricultural pests, but this involved experimenting with toxic materials such as arsenic and lead powder in the days before people took modern precautions. He died of cancer at age 56, and there is a significant chance that his work with toxic chemicals was to blame. As one commentator remarked: "Dying young, at 56, was a bad PR move, however." Fletcher never had a chance to write his memoirs, and his name faded from public view

C.G. Lloyd (1908) mused: "As we look back over the past few years, it is appalling to consider the inroads that have been made among our American mycologists by death. First, we lost J.B. Ellis, then Dr. Wm Herbst, then Professor

A.P. Morgan, then Professor L.M. Underwood and finally W.A. Kellerman." Together with individuals in this sketch who were still living, most of these individuals had personally contributed to mycology and surely through their exsiccati, publications, journals, teaching laboratories and especially students, had set mycology on an upward curve into the 20th century. But that's another story...

Epilogue

In ephemerata accompanying Hesler's (1975) compilation he kept cross-indices on particular datum points. One dealt with mycologists' birth- and death-dates and the result is telling. From 1800 through 1820, three mycological births were recorded. In the 1820s, births = three; in the 1830s, five; in the 1840s, seven; in the 1850s, 19; in the 1860s, 15 (surely a reflection of war-time); in the 1870s, 20 (see Table 1). Births after 1880 meant lives after mycology had reached critical mass.

I have augmented Hesler's original to include the names of ten (*) mycologists (or influential botanists) treated here but missing from the 1975 list. Those not mentioned or treated in depth here are denoted by ^.

Table 1. North American mycological timeline

Pre-1800s

Lewis David De Schweinitz 1780–1834
Ezra Michener 1794–1887
*John Torrey 1796–1873

1800 – 1810s

*George Engelmann 1809–1884
Charles Christopher Frost 1805 – 1880
George William Clinton 1807 – 1885
*Moses Ashely Curtis 1808–1872
*Asa Gray 1810–1888
*Charles Wright 1811–1884
*Augustus Fendler 1813–1883
*Henry William Ravenel 1814–1887
Benjamin Matlock Everhart 1818 – 1904

1820s

^George Martin 1826 – 1886 [Not G.W. Martin]
Elliott Calvin Howe 1828 – 1899
Job Bicknell Ellis 1829 – 1905

1830s

*John Macoun 1831–1920
*Fr. A.B. Langlois 1832–1900
Charles Horton Peck 1833 – 1917
William Herbst 1833 – 1906
Mary Elizabeth Banning 1832 –1901
Albert Nelson Prentiss 1836 – 1896
Andrew Price Morgan 1836 – 1907

1840s

Charles McIlvaine 1840 – 1909
^William Wirt Calkins 1842 – 1914
William Gilson Farlow 1844 – 1919
Charles Edwin Bessey 1845 – 1915
Flora Wambaugh Patterson 1847 – 1928
^Samuel Mills Tracy 1847 – 1920
Thomas Huston Macbride 1848 – 1934

1850s

William A. Kellerman 1850 – 1908
^George Edward Massee 1850 – 1917
Joseph Charles Arthur 1850 – 1942
^James Fletcher 1853– 1908
Elam Bartholomew 1852 – 1934
^Byron David Halsted 1852 – 1918
John Dearness 1852 – 1954
Lucien Marcus Underwood 1853 – 1907
Edward Willet Dorland Holway 1853 – 1923
George Francis Atkinson 1854 – 1918
Franklin Sumner Earle 1854 – 1929
^Erwin Frink Smith 1854 – 1927
^Charles Edward Fairman 1856 – 1934
*Edward T. Harper 1857–1921
^William Trelease 1857 – 1942
Howard Atwood Kelly 1858 – 1943
^Roland Thaxter 1858 – 1932
^Arthur Bliss Seymour 1859 – 1933
Curtis Gates Lloyd 1859 – 1926
Edward Angus Burt 1859 – 1939

1860s

^Samuel McCutchen Bain 1860 – 1915
Robert Almer Harper 1862 – 1946
^Louis Herman Pammel 1862 – 1931

^Ellsworth Bethel 1863 – 1925
^Beverly Thomas Galloway 1863 – 1938
^George Grant Hedgcock 1864 – 1946
Cornelius Lott Shear 1865 – 1956
^Mason Blanchard Thomas 1866 – 1912
^Howard James Banker 1866 – 1940
^Henry Curtis Beardslee 1865 – 1948
^George Perkins Clinton 1867 – 1927
^William Henry Long 1867 – 1947
^Elizabeth Eaton Morse 1864 – 1950
^William Alphonso Murrill 1869 – 1957
^Calvin H. Kauffman 1869 – 1931

1870s

^David Ross Sumstine 1870 – 1965
^Elias Judah Durand 1870 – 1922
^Robert Hagelstein 1870 – 1945
^George Richard Lyman 1871 – 1926
^Frank Lincoln Stevens 1871 – 1934
^William Sturgis Thomas ~1871 – 1941
^Charles Thom 1872 – 1956
^Gertrude Simona Burlingham 1872 – 1962
^William Chambers Coker 1872 – 1953
^Benjamin Minge Duggar 1872 – 1956
^Edward Martinius Gilbert 1872 – 1956
Louis Charles Christopher Krieger 1873 – 1940
^Frederic Edward Clements 1874 – 1943
^Arthur Henry Reginald Buller 1874 – 1944
Ernst Athern Bessey 1877 – 1957
^Vera K. Charles 1877 – 1954
^Fred Jay Seaver 1877 – 1970
^Leigh Humboldt Pennington 1877 – 1929
^Herbert Hice Whetzel 1877 – 1944

Cognizant of his pride of alma mater, Cornell, Hesler also compiled a list of schools that produced mycologists who were eligible for inclusion in his compilation (i.e. death well before 1975, and chiefly mycologists, not phytopathologists). Not surprisingly, Cornell led the list with Harvard a distant second. Personages who acted as mycological magnets were easy to identify. A short table showing school name, student name, date of degree and major professor follows (Table 2 arranged, as Hesler had it, alphabetically).

Table 2. American mycologists: educational origins and professors

Albany State Normal School			
C.H. Peck	Undergr.	1841	
C.L. Shear	Undergr.	1888	Burt
University of Chicago			
F.L. Stevens	PhD	1900	
G.W. Martin	PhD	1928	
Columbia University			
H.J. Banker	M.A.	1901	Underwood
G.S. Burlingham	PhD	1908	
R.W. Benham	PhD	1931	
F.D. Kern	PhD	1921	
Cornell University			
W.A. Kellerman	B.A.	1874	Prentiss
G.F. Atkinson	B.A.	1885	Prentiss
J.C. Arthur	D. Sci.	1886	Prentiss
E.J. Durand	D. Sci.	1895	
B.M. Duggar	PhD.	1898	Atkinson
W.A. Murrill	PhD	1900	Atkinson
H.H. Whetzel	PhD	1906	Atkinson
V.K. Charles	B.A.	1903	Atkinson
H.S. Jackson	B.A.	1905	Atkinson
C.W. Edgerton	PhD	1908	Atkinson
H.M. Fitzpatrick	PhD	1913	Atkinson
L.R. Hesler	PhD	1914	Whetzel
A.J. Mix	PhD	1916	Reddick & al.
C.E. Chardon	M.S.	1921	Fitzpatrick
J.H. Miller	PhD	1928	Fitzpatrick
Harvard University			
W.G. Farlow	B.A.	1866	Asa Gray
	M.D.	1870	
B.D. Halsted	D. Sc.	1878	Farlow
A.B. Seymour	1883–1884	Farlow	
Roland Thaxter	PhD	1888	Farlow
C.H. Kauffman	B.A.	1895	Farlow
E.A. Burt	PhD	1895	Farlow
B.M. Duggar	M.A.	1895	Farlow
G.P. Clinton	D.Sci.	1902	Farlow
W.H. Weston	PhD	1916	Farlow
D.H. Linder	PhD	1926	Thaxter
L.M. Ames	PhD	1933	Thaxter

University of Illinois			
A.B. Seymour	M.S.	1886	Burrill
F.S. Earle	M.S.	1886	Burrill
G.P. Clinton	M.S.	1894	Burrill
L.R. Tehon	PhD	1934	F.L. Stevens
Iowa State University			
Flora W. Patterson	M.A.	1895	
F.D. Kern	M.S.	1904	
F.J. Seaver	PhD	1912	
Johns Hopkins University			
W.C. Coker	PhD	1901	D. Johnson
University of Michigan			
E.F. Smith	PhD	1889	
C.H. Kauffman	PhD	1907	Newcomb
L.H. Pennington	PhD	1909	Newcomb
E.B. Mains	PhD	1916	Kauffman
D.V. Baxter	PhD	1926	Kauffman
Michigan State University			
A.N. Prentiss	B.S.	1861	
	M.S.	1864	
B.D. Halsted	M.S.	1874	Prentiss
	D.Sci.	1878	Farlow
C.E. Bessey	?	?	Prentiss
S.M. Tracy	?	?	Prentiss
University of Missouri			
Charles Thom	PhD	1899	
Monmouth College			
T.H. Macbride	B.A.	1869	
	M.A.	1873	
University of Nebraska			
E.A. Bessey	LL.D. (Hon.)	1946	
C.L. Shear	M.A.	1898	C.E. Bessey
F.E. Clements	PhD.	1898	
University of North Carolina			
W.H. Ravenel	LL.D. (Hon.)	1886	
Purdue University			
F.D. Kern	M.S.	1907	Arthur
Rutgers University			
F.L. Stevens	M.S.	1897	Halsted

University of South Carolina			
W.H. Ravenel	B.A.	1832	
Syracuse University			
L.M. Underwood	M.A.	1877	
	LL.D. (Hon.)	1906	
University of Texas			
W.H. Long	M.A.	1900	
University of Toronto			
H.W. Groves	PhD.	1935	
Union University (Schenectady, NY)			
J.B. Ellis	B.A.	1871	
C.H. Peck	B.A.	1859	
	M.A.	1862	
	D. Sc. (Hon.)	1908	
Washington University (St. Louis)			
L.H. Pammel	PhD.	1896	
L.O. Overholts	PhD.	1915	Burt
S.M. Zeller	PhD.	1917	Burt
Williams College			
M.A. Curtis	M.A.	1827	
University of Wisconsin			
E.M. Gilbert	PhD.	1907	R.A. Harper
Yale University			
N.E. Stevens	PhD.	1921	Evans
G.L. Zundel	PhD.	1928	G.P. Clinton

Acknowledgments

In the fall of 1975, Lexemuel Ray Hesler, then retired from botany department head and dean of liberal arts, strolled into my office with a thick volume informally held together by a plastic claw–like device. "You might be interested in this," he declared. "I've been working on it for some time." And with that, as was his wont, he left. The cover did not deal with some fungal genus as I might have expected. If so, he would have sent it to Alexander Hanchett Smith, his mentor and alter–ego who would have been co–author. Instead, the title started with "Biographical sketches of deceased North American mycologists..." I was surprised, for there had been no sign that he had, in fact, been working on such a volume, but most of the names featured were only names for me and as I read one or two entries I was not seized with any particular passion for his subject.

Among individuals to whom he had written for information was Clark T. Rogerson at the New York Botanical Garden, to whom he confided his intent. [Letter

dated Dec. 24, 1974, Christmas Eve]: "What I have long wanted to do is to have handy for graduate students a series of short biographies … At last, I have decided to bring together what I can, compiled from the published biographies, for our graduate students here."

In conversation later, Hesler opined that the volume of 124 thumbnail biographies ranging from a half–page to five pages, was not ready for publication because he had not exhausted available background material.

Here we are, some 43 years later, and I am at the same point in life as Hesler was then. A longtime interest has been mycological history, and it may be time to bring some of Hesler's work into a context. This paper is aimed in that direction with thanks for the inspiration and contribution.

Meredith Blackwell and Lorelei Norvell acted as outside reviewers and Lorelei spent many hours putting the manuscript in order in addition to ordinary editorial tasks. Shaun Pennycook reviewed a late version of the paper and made constructive comments.

Thanks are offered to Dr. Beth Mullen for information concerning Quaker "Plain Language." Dr. Teresa Iturriaga, Cornell University Plant Pathology Herbarium, generously furnished material on Augustus Fendler. Ms Ann Viera of the Pendergrass Agricultural Library at the University of Tennessee provided digitized copies of obituaries in early volumes of Phytopathology.

Many thanks are due to Mrs. Dorene Neilans Setliff, who, in a term paper for a natural history course, included several of the photo illustrations co-opted here. Little did she know in 1963, that over a half century later her thoroughness would still be appreciated.

In juxtaposition to Farlow's purchase of rare mycological literature and my many joyous hours in the stacks of The New York Botanical Garden's library, acknowledgment and thanks must be extended to online sources of entire runs of mycological journals (and many others), search engines, Wikipedia (although with due caution), and especially JStor and Cyberliber for hosting a plethora of literature. Index of Fungi contributes other data of great use. The research for this sketch was completed in months hardly leaving my office (although with some grieving over the inability to travel as widely as ever).

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Coronosporidium ecuadorianum gen. & sp. nov. from submerged decaying leaf from Ecuador

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Abstract—A new genus and species *Coronosporidium ecuadorianum* are described and illustrated. The fungus, found on a submerged decaying leaf of an unidentified plant, is distinguished by blastic production of stauroconidia, obpyramidal coronate, 1-septate, and inequilateral sympodial extensions of the conidiogenous cells after rhexolytic conidial secession.

Key words—asexual fungi, freshwater, hyphomycetes, taxonomy, tropics

Introduction

The diversity of microfungi in the Ecuadorian Rainforest has received little attention, especially in freshwater habitats. During a survey of hyphomycetes associated with plant litter submerged in streams from rainforest and cacao plantations near the Patul river, La Aurora (Fig. 1), Azuay province, southwest

Fig. 1. Streams in La Aurora rainforest, Azuay Province, Ecuador.

Ecuador, we collected a fungus that differs remarkably from all previously described genera (Seifert & al. 2011) for which we propose a new genus and species.

Materials & methods

Samples of decaying plant materials were collected and placed in plastic bags for transport to the laboratory, where they were washed, treated according to Castañeda-Ruiz & al. (2016), and placed in humid chambers. Several attempts to obtain this species in pure culture were unsuccessful after using a flamed needle to transfer conidia to corn meal agar mixed 1:1 with carrot extract and incubating at 25 °C. Mounts were prepared in PVL (polyvinyl alcohol, lactic acid) and measurements were made at 1000× magnification. Microphotographs were obtained with an Olympus BX51 microscope equipped with bright field and Nomarski interference optics. The type specimen is deposited in the Herbarium of Universidade Federal de Pernambuco, Recife, Brazil (URM).

Taxonomy

Coronosporidium R.F. Castañeda, Quevedo & D. Sosa, **gen. nov.**

Index Fungorum IF 554557

Differs from *Coronospora* by its polyblastic conidiogenous cells with minute separating cells attached to the conidia, which secede by rhexolytic fracture.

Type Species: *Coronosporidium ecuadorianum* R.F. Castañeda & al.

Etymology: *Corono-* (Latin) meaning crowned + *-sporidium* (Latin) referring to the conidia.

Colonies on the natural substrate effuse. Conidiophores macronematous, mononematous, unbranched, subhyaline to pale brown. Conidiogenous cells monoblastic and polyblastic, integrated, indeterminate, with holoblastic sympodial extension. Separating cells broadly cylindrical. Conidial secession rhexolytic. Conidia solitary, acrogenous or acropleurogenous, stauromorphic, coronate, gray to brown, euseptate.

Coronosporidium ecuadorianum R.F. Castañeda, Quevedo & D. Sosa, **sp. nov.** Figs 2, 3

Index Fungorum IF 554558

Differs from *Coronospora dendrocalami* by the rhexolytic conidial secession and the cylindrical basal frill of the conidia.

Type: Ecuador, Azuay province, La Aurora, 79°21 W 2°34 S, alt. 499 m, on submerged decaying leaf of an unidentified plant in stream, 4.III.2018, coll. A. Quevedo Pinos, E. Leiva Pantoja & J. Ochoa Torres (**Holotype**, URM 91191).

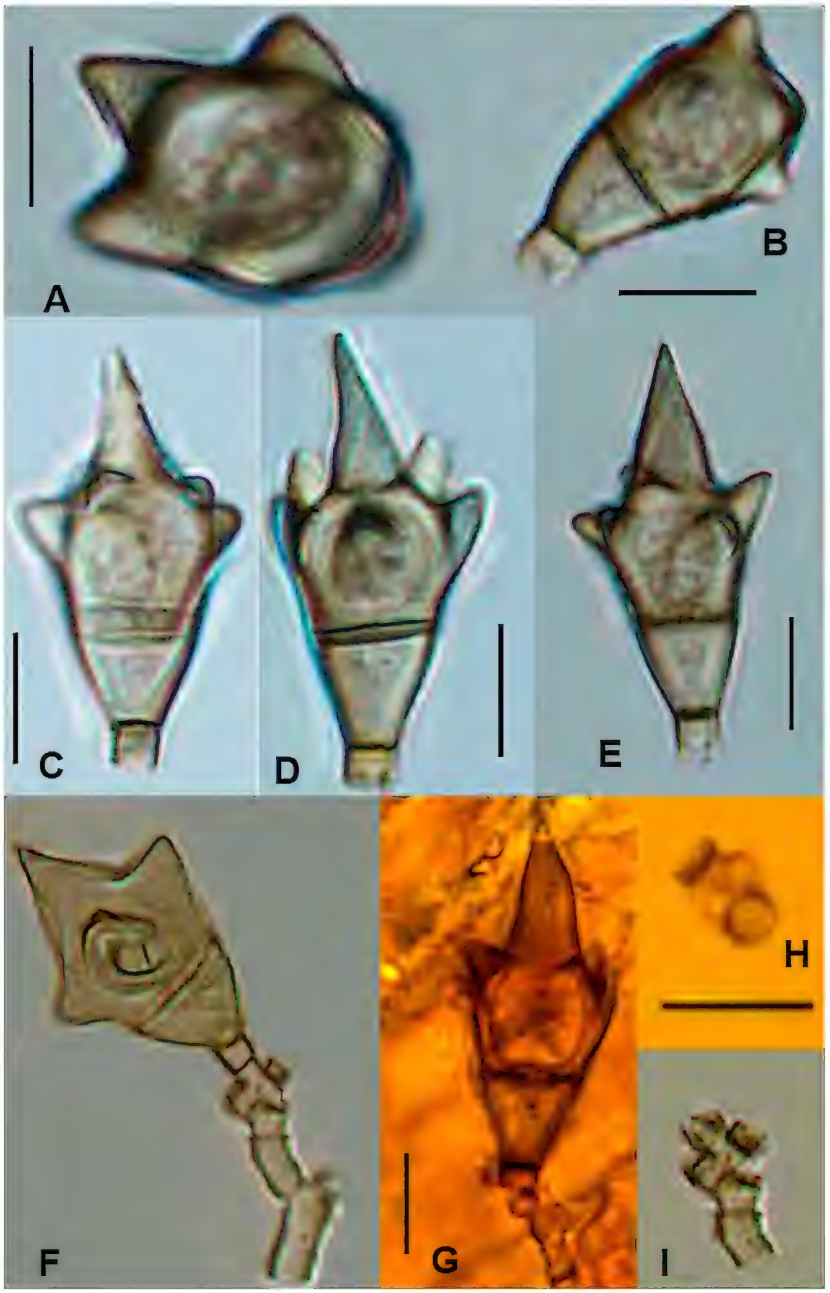
Etymology: *ecuadorianum* (Latin) referring to Ecuador, the type locality.

Colonies on the natural substrate effuse, hypophyllous, granulose, brown to golden gray brown. Mycelium superficial and immersed, composed of septate, unbranched, smooth, 2–3 µm diam, pale brown to subhyaline hyphae. Conidiophores macronematous, mononematous, erect, flexuous, straight or geniculate, unbranched, smooth, 1–3-septate, pale brown to brown, 10–30 × 3.5–4.5 µm, smooth. Conidiogenous cells polyblastic, rarely monoblastic, cylindrical, integrated, indeterminate, terminal, becoming intercalary with frequent sympodial extensions, smooth, pale brown to brown, 8–20 × 3 µm. Separating cells broadly cylindrical, pale brown or pale smoked gray brown, 4–6 µm long, fracturing and remaining as a persistent short peg. Conidial secession rhexolytic. Conidiogenous loci a conspicuous minute collar, slightly ringed after the conidial secession. Conidia solitary, acrogenous, mostly acropleurogenous, broad pyriform, broad turbinate, coronate, inequilaterally 1-euseptate, smoked gray brown to dark gray, smooth-walled, 30–40 × 20–30 µm, with a conspicuous basal frill, 2–3 µm, and toward upper part an acuminate to obtuse, subtriangular central protuberance, 5–18 µm long, encircled near the base by others 4–6 obtuse or rounded, erect or oblique, corniform protuberances, 4–8 µm long, disposed more or less radially at the apical margin.

Note: *Coronosporidium ecuadorianum* is superficially similar to *Coronospora dendrocalami* M.B. Ellis in conidial shape and the polyblastic sympodial extension of the conidiogenous cells, but *C. dendrocalami* has cicatrized, slightly melanized loci of the conidiogenous cells (Ellis 1971). *Anacoronospora diversiseptata* J.S. Monteiro & al. can also be compared with *C. ecuadorianum* in conidial shape, but *A. diversiseptata* has disto- and euseptate conidia produced after enteroblastic percurrent (sometimes sympodial) extension, and its conidiogenous loci are cicatrized and strongly melanized (Monteiro & al. 2016).

Henicospora amazonensis J.S. Monteiro & al. and *H. coronata* B. Sutton & P.M. Kirk resemble *C. ecuadorianum* in conidial shape and rhexolytic conidial secession, but the *Henicospora* species are characterized by monoblastic, determinate conidiogenous cells and the absence of ringed minute collar remnant on the conidiogenous loci (Monteiro & al. 2014, Kirk & Sutton 1980).

Fig. 2. *Coronosporidium ecuadorianum* (holotype, URM 91191). A–E. Conidia with a basal frill of the separating cells. F. Conidiogenous cells, separating cells, and attached conidium. G. Rhexolytic conidial secession in the separating cell. H, I. Conidiogenous cells with ringed collarette-like conidiogenous loci. Scale bars = 10 µm.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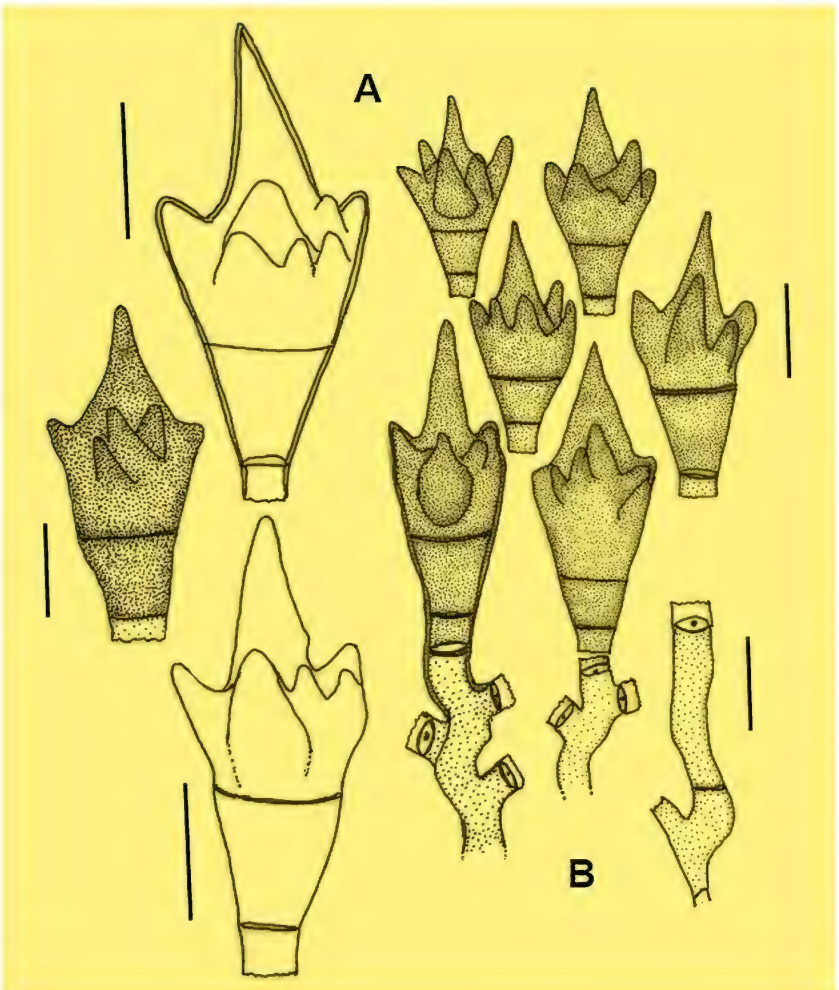

Fig. 3. *Coronosporidium ecuadorianum* (holotype, URM 91191).. A Conidia. B. Conidiogenous cells with the ringed collarette-like conidiogenous loci. Scale bars = 10 µm.

The rhexolytic fracture and ringed, minute collar remnant on the loci in *C. ecuadorianum* are almost the same as observed in *Matsushimiella paraensis* J.S. Monteiro & al. and *M. queenslandica* (Matsush.) R.F. Castañeda & Heredia, but those species have phragmoconidia, which are distoseptate, ellipsoidal, obovate, long ovoid, or oblong, and lacking the conidial arms (Castañeda-Ruiz & al. 2001, Matsushima 1989, Monteiro & al. 2015a,b).

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Trichoglossum tetrasporum, newly recorded from India

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Abstract—The uncommon earth tongue, *Trichoglossum tetrasporum*, is recorded for the first time from India. Macroscopic and microscopic characters of the species are described and illustrated along with its world distribution.

Key words—apothecia, *Geoglossaceae*, *Geoglossales*, paraphyses, setae

Introduction

Earth tongues (*Geoglossomycetes;* Schoch & al. 2009) are a widely distributed group of fungi that have been under intense investigation since the descriptions of *Geoglossum* Pers. in the late 18th century and *Trichoglossum* Boud. in the late 19th century. The widely distributed group includes such genera as *Geoglossum*, *Nothomitra* Maas Geest., *Sarcoleotia* S. Ito & S. Imai, and *Trichoglossum* (Schoch & al. 2009, Hustad & al. 2011).

Trichoglossum is separated from *Geoglossum* based on the production of abundant dark setae (hairs) in the hymenium and on the stipe (Mains 1954, Sinden & Fitzpatrick 1930). About 19 *Trichoglossum* species are currently recognized (Kirk & al. 2008, Hustad & al. 2013), although Index Fungorum (2018) lists 23 species and 48 varieties, which include a number of synonyms and dubious taxa (Hustad & al. 2013).

Sinden & Fitzpatrick (1930) described *Trichoglossum tetrasporum* from New York State, USA. It has since been reported from China (Tai 1944, Mains 1954), Great Britain (Nannfeldt 1942), Netherlands (Maas Geesteranus 1964), Denmark (Benkert 1976), Spain (Gálan & Rubio 1998), and Italy (Lantieri 2011). Here we extend its distribution range to India. The macro- and micro-morphological features of the Indian collection are described and illustrated below.

Materials & methods

Collection area

The samples were collected from Suryamaninagar (23°45.70′N 91°15.79′E; 80 m asl), West Tripura, Northeast Region, India. Tripura, one of seven states in north-eastern India, occupies a geographical area of 10,491 km^2, of which 6292 km^2 (c. 60%) is covered with forest. The state is located at 22°57′–24°33′N 91°10′–92°20′E. Its climate averages are: temperature 10°C–35°C, relative humidity 50–80%, and annual rainfall 2100 mm.

Specimen collection and identification

The specimens were collected from natural habitats using forceps and photographed. The apothecia and ascogenous portions were measured just after collection from field. Samples were dried for 24 hours at 45–55°C in a ROV/DG hot-air oven. After drying, samples were preserved for further analysis in a polyethylene bag also containing 1,4-dichlorobenzene (Debnath & al. 2017). The dried material was preserved in the Mycology and Plant Pathology laboratory, Department of Botany, Tripura University, bearing the collection tag MCCT (Mushroom Culture Collection Tube)-380. A small portion of a hand-sectioned specimen was squash-mounted in 5% potassium hydroxide (KOH) solution. Slides were also mounted in Melzer's reagent, Lugol's solution, and lactoglycerol and Congo Red solution for observation of anatomical characters under an Olympus CX21i bright field microscope equipped with a SLI500 camera. Diagnostic features including the asci, ascospores, paraphyses and setae were studied and compared with different descriptions for identification (Sinden & Fitzpatrick 1930, Mains 1954, Maas Geesteranus 1965). The collection was deposited in Central National Herbarium, Botanical Survey of India, Howrah, West Bengal, India (CAL).

Taxonomy

Trichoglossum tetrasporum Sinden & Fitzp., Mycologia 22: 60 (1930) Figs 1, 2

Apothecia scattered to gregarious, black or brownish black, clavate to capitate, 10–90 mm long; head compressed, 20–40 × 20–30 mm diam., hirsute from setae; odourless. Sterile portion or stipe cylindrical, slender, 2–3 mm thick, hirsute from setae. Asci clavate, 4-spored, 170–195 × 16–20 µm, rounded

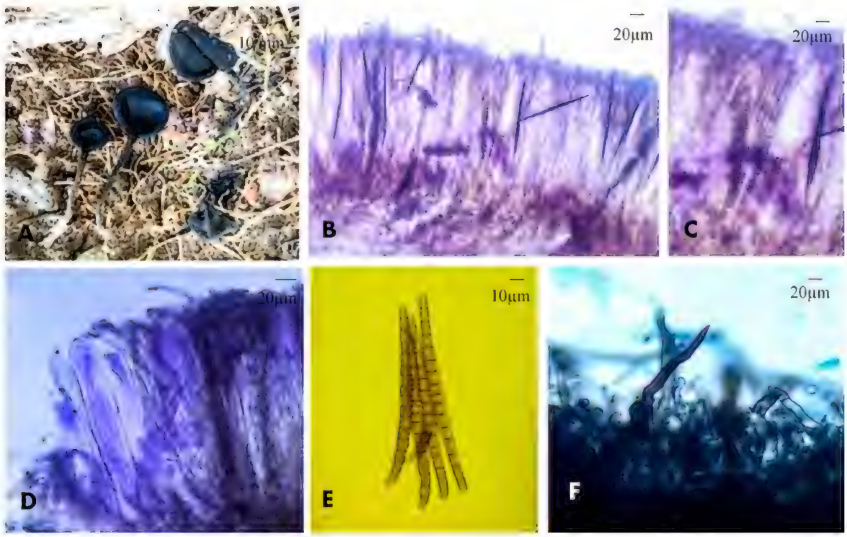

FIG. 1. *Trichoglossum tetrasporum* (CAL 1687): A. Mature fruit body in natural habitat; B. Cross section of head showing mature asci, setae, and paraphyses; C. 4-spored asci, dark brown setae, and bulbous paraphyses with curved capitate tips; D. Immature stage of asci with paraphyses; E. Slightly curved ascospores with 15 transverse septa; F. Irregularly flexuous setae of stipe. Scale bars: A = 10 mm; B–D, F = 20 µm; E = 10 µm.

at apex, short-pedicellate. ASCOSPORES parallelly arranged in the upper part of the ascus; fusoid to subcylindrical, smooth, 130–145 × 5–7 µm, with 10–15 transverse septa when mature (fewer when immature), slightly curved, dark brown when mature; apical ends narrowed and rounded; individual cells often uniguttulate. HYMENIAL SETAE 180–220 × 5–13 µm, smooth, straight to flexuous. PARAPHYSES 2–4 µm wide, sub-cylindrical toward the bottom but often with some swollen, filamentous, septate, and curved at tips. STIPE SETAE irregularly waved outline, dark brown, measuring 170–200 × 4–12 µm.

SPECIMEN EXAMINED: **INDIA**, **NORTHEAST REGION**, **West Tripura**, Suryamaninagar, 23°45.70 N 91°15.79 E, 80 m asl, saprobic on soil with decomposed plants, 18 September 2017, Debnath & Saha (CAL 1687).

DISTRIBUTION: *Trichoglossum tetrasporum* has been reported from USA, Great Britain, Netherlands, Denmark, Spain, Italy, China, and India.

Discussion

Trichoglossum tetrasporum is characterized by a hymenium with numerous acuminate brown setae, 4-spored asci, and 10–15-septate ascospores. It is

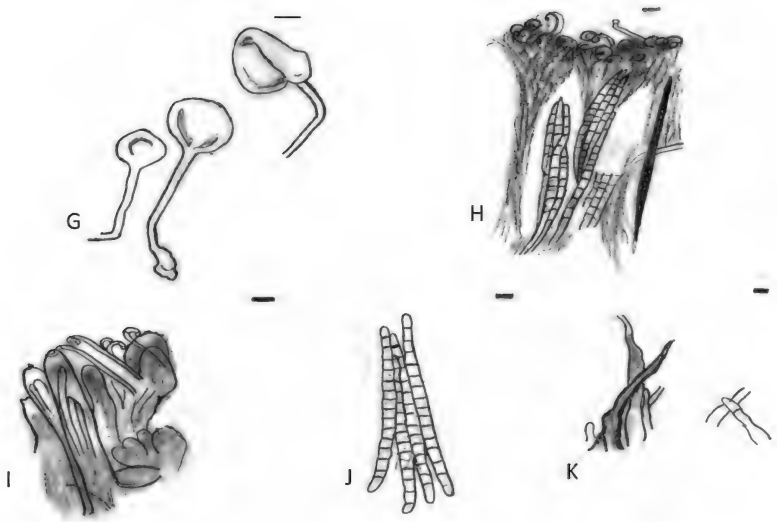

Fig. 2. *Trichoglossum tetrasporum* (CAL 1687): G. Mature fruit body; H. 4-spored asci, setae, and bulbous paraphyses with curved capitate tips; I. Immature stage of asci with paraphyses; J. Slightly curved ascospores with 15 transverse septa; K. Irregularly flexuous setae of stipe. Scale bars: G = 10 mm; H, I, K = 20 µm; J = 10 µm.

morphologically quite close to *T. hirsutum* (Pers.) Boud. and *T. velutipes* (Peck) E.J. Durand but is distinguished by the size of asci and ascospores and number of ascospore septa. Most authors report 15 septa for *T. tetrasporum* ascospores (Sinden & Fitzpatrick 1930, Seaver 1951, Ellis & Ellis 1988, Gálan & Rubio 1998), which mostly corresponds with our findings. Mains (1954), however, reported a much more variable number of septa (0–17) for the species.

Tai (1944) described *Trichoglossum tetrasporum* var. *brevisporum* F.L. Tai and *T. yunnanense* F.L. Tai from Yunnan, China. His description of *T. tetrasporum* var. *brevisporum* showed similarities with our specimen but differed by its smaller ascospores (117–137 × 6–7 µm); and his description of *T. yunnanense* differed from *T. tetrasporum* by its longer and narrower asci (237–294 × 19–22 µm) and its longer (143–187 × 6–7 µm) and differently shaped (cylindrical clavate) ascospores. However, Mains (1954) considered *T. yunnanense* to represent "a longer, more variable, septate-spored variant of *T. tetrasporum*," and recombined it as *T. tetrasporum* var. *yunnanense* (F.L. Tai) Mains. Species Fungorum (2018) accepts both names as varieties of *T. tetrasporum*.

A literature survey found no report of *T. tetrasporum* from Asia other than Tai (1944); our record from India therefore represents only the second Asian report in 74 years.

Prabhugaonkar & Pratibha (2017) documented a new record of *T. rasum* Pat. from Asia, also providing a preliminary phylogeny of *Trichoglossum* showing *T. hirsutum* as polyphyletic, in concordance with previous findings by Hustad & al. (2013). Phylogenetic investigations of *T. tetrasporum* from different continents may clarify whether the differences in spore size and septation reported by different authors represent one highly variable species with a wide distribution or include one or more cryptic species.

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Perenniporia mopanshanensis sp. nov. from China

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Abstract—A new poroid, white-rot, wood-inhabiting fungal species, *Perenniporia mopanshanensis*, is proposed based on morphological and molecular characters. This species from Yunnan Province, China, is characterized by resupinate basidiomes with a cream to buff to straw pore surface, dimitic hyphal system with strongly dextrinoid, unbranched, interwoven skeletal hyphae, and ellipsoid, non-truncate basidiospores (5.5–6.5 × 4–5 µm) with hyaline, distinctly thick, smooth, strongly dextrinoid walls. Phylogenetic analyses of ITS+nLSU sequences showed that *P. mopanshanensis* is a distinct taxon in the *Perenniporia* sensu stricto clade and is sister to *P. bannaensis*.

Key words—molecular phylogenetics, *Polyporaceae*, taxonomy, *Truncospora*, wood-rotting fungi

Introduction

Perenniporia Murrill (*Polyporaceae*, *Polyporales*) is a large cosmopolitan genus characterized by poroid basidiomata with thick-walled, ellipsoid to distinctly truncate basidiospores that are cyanophilous and with variable dextrinoid reactions (Ryvarden 1991). The *Perenniporia* hyphal system is di- or trimitic: the generative hyphae with clamp connections and the skeletal hyphae with walls that are cyanophilous and variably dextrinoid (Decock & Stalpers 2006). About 100 species are accepted in the genus (Gilbertson & Ryvarden 1987; Hattori & Lee 1999; Núñez & Ryvarden 2001; Dai & al. 2002, 2011; Cui & al. 2007; Xiong & al. 2008; Choeyklin & al. 2009; Decock 2011, 2016; Zhao & al. 2013; Ryvarden & Melo 2014; Jang & al. 2015; Ji & al. 2017).

Recently, phylogenetic studies of *Perenniporia* based on sequences of the internal transcribed spacer (ITS) region and the large subunit nuclear ribosomal RNA gene (nLSU) have revealed several well-supported clades that could be recognized as distinct genera (Robledo & al. 2009, Zhao & al. 2013). Robledo & al. (2009) demonstrated that *Perenniporia* was phylogenetically related to *Abundisporus* Ryvarden, *Hornodermoporus* Teixeira, *Perenniporiella* Decock & Ryvarden, and *Truncospora* Pilát, while Zhao & al. (2013) have shown that *Perenniporia* itself is polyphyletic. Several new species of *Perenniporia* have been described based on ribosomal DNA sequences (Zhao & Cui 2013, Jang & al. 2015, Ji & al. 2017)

During research on polypore diversity in southern China, an undescribed species of *Perenniporia* was found. We present morphological and molecular phylogenetic evidence that support the recognition of *P. mopanshanensis* as a new species.

Materials & methods

The specimens studied are deposited at the herbarium of Southwest Forestry University, Kunming, China (SWFC). Basidiomatal descriptions are based on field notes. Special colour terms follow Petersen (1996). Anatomical observations were obtained from the dried specimens and made using a light microscope following Dai (2010). The following abbreviations were used: KOH = 5% potassium hydroxide, CB = cotton blue, CB– = acyanophilous, IKI = Melzer's reagent, IKI– = both inamyloid and non-dextrinoid, L = mean spore length (arithmetic average of all spores), W = mean spore width (arithmetic average of all spores), Q = variation in the L/W ratios between the specimens studied, n (a/b) = number of spores (a) measured from given number (b) of specimens.

The Omega EZNA HP Fungal DNA Kit was used to obtain genomic DNA from dried specimens according to the manufacturer's instructions with some modifications. A 30 mg sample from a dried fungal specimen was ground to powder with liquid nitrogen. The powder was transferred to a 1.5 ml centrifuge tube, suspended in 0.4 ml of lysis buffer, and incubated in a 65°C water bath for 60 min. After that, 0.4 ml phenol-chloroform (24:1) was added to each tube, and the suspension was shaken vigorously. After centrifugation at 13,000 rpm for 5 min, 0.3 ml supernatant was transferred to a new tube and mixed with 0.45 ml binding buffer. This mixture was transferred to an adsorbing column (AC) for centrifugation at 13,000 rpm for 0.5 min. Then, 0.5 ml inhibitor removal fluid was added in AC for a centrifugation at 12,000 rpm for 0.5 min. After washing twice with 0.5 ml washing buffer, the AC was transferred to a clean centrifuge tube, and 100 ml elution buffer was added to the middle of adsorbed film to elute the genomic DNA. ITS region was amplified with primer pairs ITS5 and ITS4 (White & al. 1990). Nuclear LSU region was amplified with primer pairs LR0R and LR7 (http://www.biology.duke.edu/fungi/mycolab/primers.htm). The ITS region

was amplified by initial denaturation at 95°C for 3 min, then 35 cycles of 94°C for 40 s, 58°C for 45 s, and 72°C for 1 min with a final extension of 72°C for 10 min. The nLSU region was amplified by initial denaturation at 94°C for 1 min, then 35 cycles at 94°C for 30 s, 48°C for 1 min, and 72°C for 1.5 min, ending with a final extension of 72°C for 10 min. The PCR products were purified and directly sequenced at Kunming Tsingke Biological Technology Limited Company. All newly generated sequences were deposited at GenBank (Table 1).

Table 1. Species, specimens, and GenBank accession numbers of studied sequences

Species name	Sample no.	GenBank accession no.		Reference
		ITS	nLSU	
A. sclerosetosus	MUCL 41438	FJ411101	FJ393868	Robledo & al. 2009
A. violaceus	MUCL 38617	FJ411100	FJ393867	Robledo & al. 2009
Donkioporia expansa	MUCL 35116	FJ411104	FJ393872	Robledo & al. 2009
Hornodermoporus "latissimus"	Cui 6625	HQ876604	JF706340	Zhao & al. 2013
H. martius	Cui 7992	HQ876603	HQ654114	Zhao & al. 2013
	MUCL 41677	FJ411092	FJ393859	Robledo & al. 2009
	MUCL 41678	FJ411093	FJ393860	Robledo & al. 2009
Microporellus violaceocinerascens	MUCL 45229	FJ411106	FJ393874	Robledo & al. 2009
Perenniporia africana	Cui 8674	KF018119	KF018128	Present study
	Cui 8676	KF018120	KF018129	Present study
P. aridula	Dai 12398	JQ001855	JQ001847	Zhao & al. 2013
	Dai 12396	JQ001854	JQ001846	Zhao & al. 2013
P. bannaensis	Cui 8560	JQ291727	JQ291729	Zhao & al. 2013
	Cui 8562	JQ291728	JQ291730	Zhao & al. 2013
P. cinereofusca	Dai 9289	KF568893	KF568895	Zhao & al. 2013
	Cui 5280	KF568892	KF568894	Zhao & al. 2013
P. corticola	Cui 1248	HQ848472	HQ848482	Zhao & al. 2013
	Dai 7330	HQ654094	HQ654108	Cui & Zhao 2013
	Cui 2655	HQ654093	HQ848483	Cui & Zhao 2013
P. ellipsospora	Cui 10276	KF018124	KF018132	Present study
	Cui 10284	KF018125	KF018133	Present study
P. hainaniana	Cui 6364	JQ861743	JQ861759	Zhao & Cui 2013
	Cui 6365	JQ861744	JQ861760	Zhao & Cui 2013
	Cui 6366	JQ861745	JQ861761	Zhao & Cui 2013
P. koreana	KUC 200932	KJ156313	KJ156305	Jang & al. 2015
	KUC 2008J-02	KJ156310	KJ156302	Jang & al. 2015
P. lacerata	Cui 7220	JX141448	JX141458	Zhao & Cui 2013
	Dai 11268	JX141449	JX141459	Zhao & Cui 2013
P. luteola	H 1308a	JX141456	JX141466	Zhao & Cui 2013
	H 1308b	JX141457	JX141467	Zhao & Cui 2013
P. maackiae	Cui 8929	HQ654102	JF706338	Zhao & Cui 2013
	Cui 5605	JN048760	JN048780	Zhao & Cui 2013
P. macropora	Zhou 280	JQ861748	JQ861764	Zhao & Cui 2013
P. medulla-panis	MUCL 49581	FJ411088	FJ393876	Robledo & al. 2009
	MUCL 43250	FJ411087	FJ393875	Robledo & al. 2009
	Cui 3274	JN112792	JN112793	Zhao & al. 2013

P. mopanshanensis	**CLZhao 5145**	**MH784912**	**MH784916**	**Present study**
	CLZhao 5152	**MH784913**	**MH784917**	**Present study**
	CLZhao 2404 [T]	**MH784911**	**MH784915**	**Present study**
	CLZhao 2311	**MH784910**	**MH784914**	**Present study**
P. nanlingensis	Cui 7620	HQ848477	HQ848486	Zhao & Cui 2013
	Cui 7589	HQ848478	HQ848487	Zhao & Cui 2013
P. pyricola	Cui 9149	JN048762	JN048782	Zhao & Cui 2013
	Dai 10265	JN048761	JN048781	Zhao & Cui 2013
P. rhizomorpha	Dai 7248	JF706330	JF706348	Zhao & Cui 2012
	Cui 7507	HQ654107	HQ654117	Zhao & Cui 2013
P. russeimarginata	Yuan 1244	JQ861750	JQ861766	Zhao & Cui 2013
P. straminea	Cui 8718	HQ876600	JF706335	Zhao & Cui 2013
	Cui 8858	HQ654104	JF706334	Zhao & Cui 2013
P. subacida	Dai 8224	HQ876605	JF713024	Zhao & al. 2013
	Cui 3643	FJ613655	AY336753	Zhao & al. 2013
	MUCL 31402	FJ411103	AY333796	Robledo & al. 2009
P. subadusta	Cui 8459	HQ876606	HQ654113	Zhao & al. 2013
P. substraminea	Cui 10177	JQ001852	JQ001844	Zhao & al. 2013
	Cui 10191	JQ001853	JQ001845	Zhao & al. 2013
P. subtephropora	Dai 10962	JQ861752	JQ861768	Zhao & Cui 2013
	Dai 10964	JQ861753	JQ861769	Zhao & Cui 2013
P. tenuis	Wei 2783	JQ001858	JQ001848	Zhao & al. 2013
	Wei 2969	JQ001859	JQ001849	Zhao & al. 2013
P. tephropora	Cui 9029	HQ876601	JF706339	Zhao & Cui 2013
	Cui 6331	HQ848473	HQ848484	Zhao & Cui 2013
P. tibetica	Cui 9459	JF706327	JF706333	Zhao & Cui 2013
P. truncatospora	Cui 6987	JN048778	HQ654112	Zhao & Cui 2013
	Dai 5125	HQ654098	HQ848481	Zhao & Cui 2013
Perenniporiella chaquenia	MUCL 47647	FJ411083	FJ393855	Robledo & al. 2009
	MUCL 47648	FJ411084	FJ393856	Robledo & al. 2009
Pe. micropora	MUCL 43581	FJ411086	FJ393858	Robledo & al. 2009
Pe. neofulva	MUCL 45091	FJ411080	FJ393852	Robledo & al. 2009
Pe. pendula	MUCL 46034	FJ411082	FJ393853	Robledo & al. 2009
Pyrofomes demidoffii	MUCL 41034	FJ411105	FJ393873	Robledo & al. 2009
Truncospora detrita	MUCL 42649	FJ411099	FJ393866	Robledo & al. 2009
T. macrospora	Cui 8106	JX941573	JX941596	Zhao & al. 2013
T. ochroleuca	Dai 11486	HQ654105	JF706349	Zhao & al. 2013
	MUCL 39726	FJ411098	FJ393865	Robledo & al. 2009
	MUCL 39563	FJ411097	FJ393864	Robledo & al. 2009
T. ohiensis	Cui 5714	HQ654103	HQ654116	Zhao & al. 2013
	MUCL 41036	FJ411096	FJ393863	Robledo & al. 2009
Vanderbylia "delavayi"	Dai 6891	JQ861738	KF495019	Zhao & al. 2013
V. fraxinea	DP 83	AM269789	AM269853	Robledo & al. 2009
	Cui 7154	HQ654095	HQ654110	Zhao & al. 2013
	Cui 8885	HQ876611	JF706344	Zhao & al. 2013
	Cui 8871	JF706329	JF706345	Zhao & al. 2013
V. "robiniophila"	Cui 5644	HQ876609	JF706342	Zhao & al. 2013
	Cui 7144	HQ876608	JF706341	Zhao & al. 2013
	Cui 9174	HQ876610	JF706343	Zhao & al. 2013
V. vicina	MUCL 44779	FJ411095	AF518666	Robledo & al. 2009

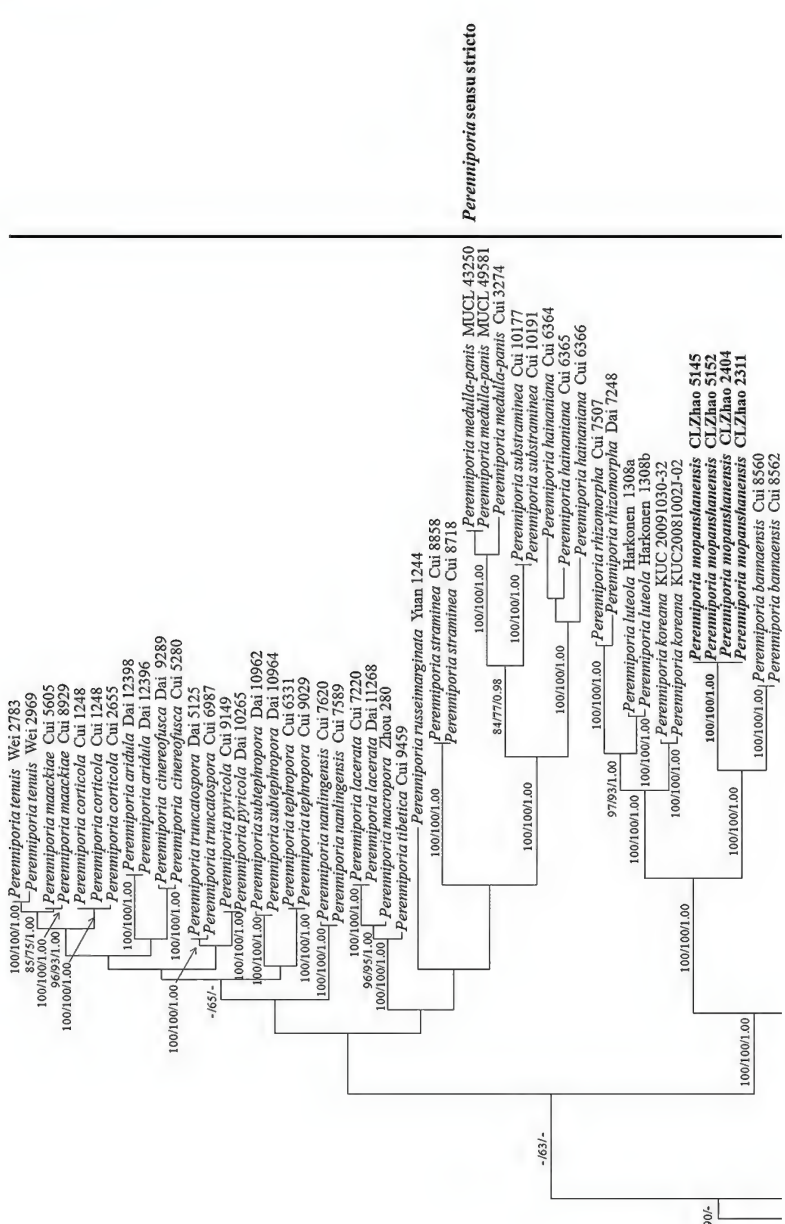
Sequencher 4.6 (GeneCodes, Ann Arbor, MI, USA) was used to edit the DNA sequence. Sequences were aligned in MAFFT 7 using the "G-INS-I" strategy (https://mafft.cbrc.jp/alignment/server/index.html) and manually adjusted in BioEdit (Hall 1999). The sequence alignment was deposited in TreeBase (submission ID 22900). *Donkioporia expansa* (Desm.) Kotl. & Pouzar and *Pyrofomes demidoffii* (Lév.) Kotl. & Pouzar were used as outgroup to root trees following Zhao & al. (2013) in the ITS+nLSU analyses.

ITS+nLSU sequence analyses were performed using maximum parsimony, maximum likelihood, and Bayesian inference methods. Maximum parsimony (MP) analyses followed Song & al. (2016), and tree construction was performed in PAUP* version 4.0b10 (Swofford 2002). All characters were equally weighted, with gaps treated as missing data. Trees were inferred using the heuristic search option with TBR branch swapping and 1000 random sequence additions. Max-trees was set to 5000, branches of zero length were collapsed, and all parsimonious trees were saved. Clade robustness was assessed using bootstrap (BT) analysis with 1000 replicates (Felsenstein 1985). Tree length (TL), consistency index (CI), retention index (RI), rescaled consistency index (RC), and homoplasy index (HI) were calculated for each Maximum Parsimonious Tree (MPT) generated. Sequences were analyzed using Maximum Likelihood (ML) with RAxML-HPC2 through the Cipres Science Gateway (www.phylo.org; Miller & al. 2009). Branch support (BS) for ML analysis was determined by 1000 bootstrap replicates.

MrModeltest 2.3 (Posada & Crandall 1998, Nylander 2004) was used to determine the best-fit evolution model for each data set for Bayesian inference (BI), which was calculated with MrBayes_3.1.2 using a general time reversible (GTR) model of DNA substitution and a gamma distribution rate variation across sites (Ronquist & Huelsenbeck 2003). Four Markov chains were run for 2 runs from random starting trees for 7 million generations (ITS+nLSU), and trees were sampled every 100 generations. The first 25% of the generations was discarded as burn-in. A majority rule consensus tree of all remaining trees was calculated. Branches that received bootstrap support for maximum likelihood (BS), maximum parsimony (BT), and Bayesian posterior probabilities (BPP) greater than or equal to 75% (BS, BT) and 0.95 (BPP) were considered significantly supported.

Molecular phylogeny

The ITS+nLSU dataset included sequences from 86 fungal specimens representing 46 species (Table 1). The dataset had an aligned length of 2100 characters, of which 1553 characters were constant, 86 variable and parsimony-uninformative, and 461 parsimony-informative. Maximum parsimony analysis yielded four equally parsimonious trees (TL = 1925, CI = 0.375, HI = 0.525, RI = 0.745, RC = 0.275). Best model for the ITS+nLSU dataset estimated and applied in the Bayesian analysis: GTR+I+G. Bayesian analysis and ML analysis produced similar topologies to MP analysis, with an average standard deviation of split frequencies = 0.006258 (BI).


Perenniporia sensu stricto
Perenniporia tenuis Wei 2783
Perenniporia tenuis Wei 2969
Perenniporia maackiae Cui 5605
Perenniporia maackiae Cui 8929
Perenniporia corticola Cui 1248
Perenniporia corticola Cui 1248
Perenniporia corticola Cui 2655
Perenniporia aridula Dai 12398
Perenniporia aridula Dai 12396
Perenniporia cinereofusca Dai 9289
Perenniporia cinereofusca Cui 5280
Perenniporia truncatospora Dai 5125
Perenniporia truncatospora Cui 6987
Perenniporia pyricola Cui 9149
Perenniporia pyricola Dai 10265
Perenniporia subtephropora Dai 10962
Perenniporia subtephropora Dai 10964
Perenniporia tephropora Cui 6331
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Perenniporia nanlingensis Cui 7620
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Perenniporia lacerata Cui 7220
Perenniporia lacerata Dai 11268
Perenniporia macroporа Zhou 280
Perenniporia tibetica Cui 9459
Perenniporia russeimarginata Yuan 1244
Perenniporia straminea Cui 8858
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Perenniporia medulla-panis MUCL 43250
Perenniporia medulla-panis MUCL 49581
Perenniporia medulla-panis Cui 3274
Perenniporia substraminea Cui 10177
Perenniporia substraminea Cui 10191
Perenniporia hainaniana Cui 6364
Perenniporia hainaniana Cui 6365
Perenniporia hainaniana Cui 6366
Perenniporia rhizomorpha Cui 7507
Perenniporia rhizomorpha Dai 7248
Perenniporia luteola Harkonen 1308a
Perenniporia luteola Harkonen 1308b
Perenniporia koreana KUC 20091030-32
Perenniporia koreana KUC20081002I-02
Perenniporia mopanshanensis CLZhao 5145
Perenniporia mopanshanensis CLZhao 5152
Perenniporia mopanshanensis CLZhao 2404
Perenniporia mopanshanensis CLZhao 2311
Perenniporia bannaensis Cui 8560
Perenniporia bannaensis Cui 8562
100/100/1.00
85/75/1.00
100/100/1.00
96/93/1.00
100/100/1.00
100/100/1.00
100/100/1.00
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-/65/-
100/100/1.00
100/100/1.00
100/100/1.00
96/95/1.00
100/100/1.00
100/100/1.00
100/100/1.00
100/100/1.00
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100/100/1.00
-/63/-
93/90/-

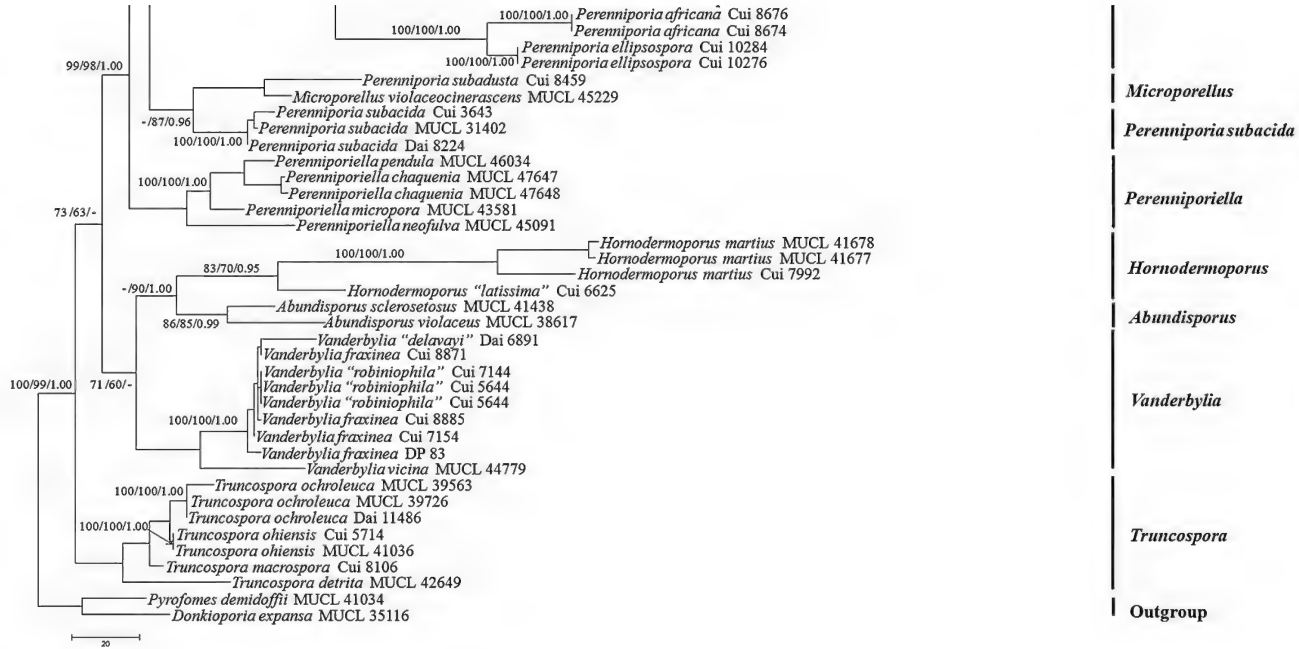

FIG. 1. Maximum Parsimony strict consensus tree illustrating the phylogeny of *Perenniporia mopanshanensis* and related species in *Polyporales* based on ITS+nLSU sequences. Branches are labeled with maximum likelihood bootstrap >70%, parsimony bootstrap proportions >50% and Bayesian posterior probabilities >0.95.

The ITS+nLSU phylogeny places *Perenniporia mopanshanensis* in the *Perenniporia* sensu stricto clade (Fig. 1), where it forms a strongly supported monophyletic lineage (BS = 100%; BT = 100%; BPP = 1) and is sister to *P. bannaensis* B.K. Cui & C.L. Zhao.

Taxonomy

Perenniporia mopanshanensis C.L. Zhao, **sp. nov.** Figs 2, 3

MycoBank MB 827580

Differs from *Perenniporia luteola* by its larger pores, its smaller basidiospores, and its unbranched skeletal hyphae.

Type: China. Yunnan Province: Yuxi, Xinping county, Mopanshan National Forestry Park, on an angiosperm trunk, 19 August 2017, C.L. Zhao 2404 (**Holotype**, SWFC 002404; GenBank MH784911, MH784915).

Etymology: The specific epithet *mopanshanensis* (Lat.) refers to the locality (Mopanshan) of the type specimen.

Basidiomata perennial, resupinate, without odor or taste when fresh, becoming corky upon drying, ≤15 × 6 cm, 8 mm thick at center. Pore surface cream when fresh, cream to buff to straw upon drying; pores round, 3–5 per mm; dissepiments thin, entire. Sterile margin narrow, cream, ≤0.5 mm wide. Subiculum cream, thin, each layer ≤0.5 mm thick. Tubes cream to buff, corky, each layer ≤2 mm long.

Hyphal structure dimitic; generative hyphae with clamp connections; skeletal hyphae strong dextrinoid, CB+; tissues unchanged in KOH.

Subiculum generative hyphae infrequent, hyaline, thin-walled, unbranched, 2–3 μm in diam.; skeletal hyphae dominant, hyaline, thick-walled with a narrow to wide lumen, unbranched, interwoven, 2–3.5 μm in diam.

Tube generative hyphae infrequent, hyaline, thin-walled, unbranched, 1.5–3 μm in diam.; skeletal hyphae dominant, hyaline, thick-walled with a narrow to wide lumen, unbranched, interwoven, 2–3.5 μm. Plenty of crystals present among hyphae. Cystidia absent, fusoid cystidioles present, hyaline, thin-walled, 13–19 × 4.5–6.5 μm; basidia barrel-shaped to clavate, with four sterigmata and a basal clamp connection, 14–20 × 7–12 μm; basidioles dominant, mostly pear-shaped, but slightly smaller than basidia.

Basidiospores ellipsoid, non-truncate, hyaline, distinctly thick-walled, smooth, strong dextrinoid, CB+, (5–)5.5–6.5(–7) × 4–5(–5.5) μm, L = 6.15 μm, W = 4.6 μm, Q = 1.35–1.42 (n = 120/4).

Type of rot: white rot.

Additional specimens examined: **CHINA. Yunnan province. Yuxi:** Xinping county, Mopanshan National Forestry Park, on the angiosperm trunk, 19 August 2017,

Fig. 2. *Perenniporia mopanshanensis* (holotype, SWFC 002404). Basidiomata. Scale bar: 3 cm.

C.L. Zhao 2311 (SWFC 002311; GenBank MH784910, MH784914); 13 January 2018, C.L. Zhao 5145 (SWFC 005145; GenBank MH784912, MH784916); C.L. Zhao 5152 (SWFC 005152; GenBank MH784913, MH784917).

Discussion

The new species, *Perenniporia mopanshanensis,* is supported by phylogenetic analyses and morphological characters. In the ITS+nLSU analyses (Fig. 1), it forms a strongly supported monophyletic lineage (BS = 100%; BT = 100%; BPP = 1) where it forms a clade with *P. bannaensis*. However, morphologically *P. bannaensis* differs from *P. mopanshanensis* by its annual basidiocarps with buff-yellow to pinkish buff pore surface and smaller pores (6–8 per mm; Zhao & al. 2013).

Morphologically, the presence of non-truncate basidiospores is shared by several other species in *Perenniporia* sensu stricto: *P. africana* Ipulet & Ryvarden, *P. ellipsospora* Ryvarden & Gilb., *P. koreana* Y. Jang & J.J. Kim, *P. luteola* B.K. Cui & C.L. Zhao, *P. rhizomorpha* B.K. Cui & al., and *P. subacida* (Peck) Donk. A morphological comparison between *P. mopanshanensis* and these six species is presented in Table 2.

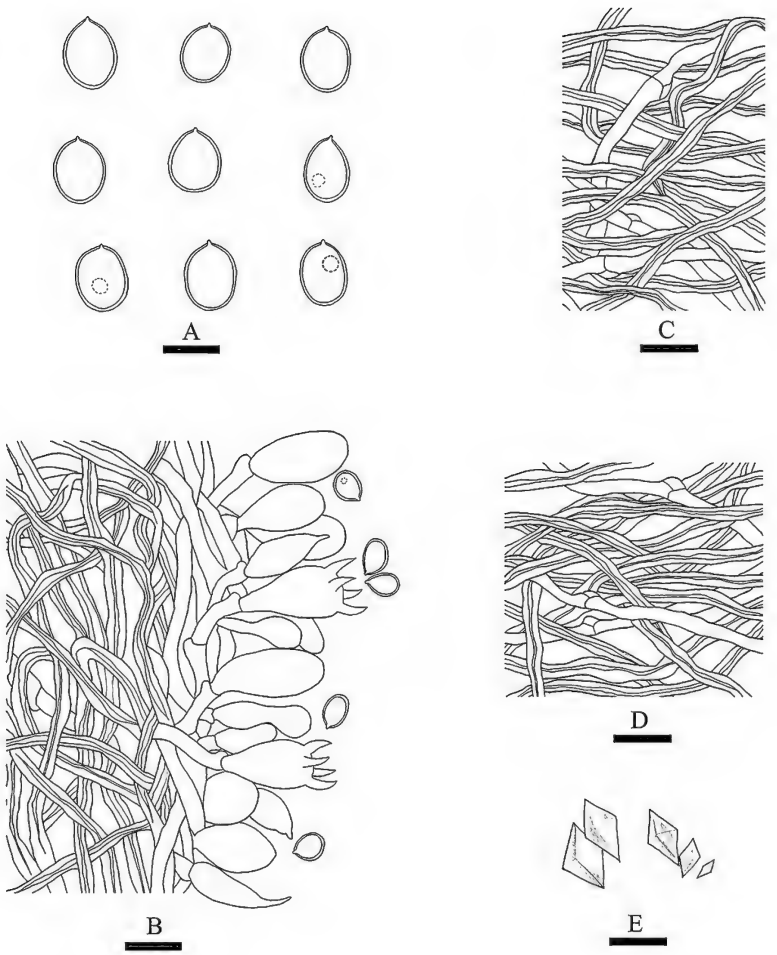

Fig. 3. *Perenniporia mopanshanensis* (holotype, SWFC 002404). A. Basidiospores; B. Section of hymenium; C. Hyphae from trama; D. Hyphae from subiculum; E. Rhombic crystal. Scale bars: a = 5 μm; b–e = 10 μm.

Polypores are an extensively studied group in *Basidiomycota* (Gilbertson & Ryvarden 1987, Núñez & Ryvarden 2001, Ryvarden & Melo 2014), but Chinese polypore diversity is still not well known, especially in the subtropics and tropics. The new species, *Perenniporia mopanshanensis,* was found in the Chinese subtropics, where many new taxa in the *Polyporales* and *Hymenochaetales* have

Table 2. A comparison of *Perenniporia* species with non-truncate basidiospores

Species	Habit	Pore surface	Pores / mm	Spores (µm)	Skeletal hyphae	Reference
africana	Annual	Pale orange to brown	6–8	4–5 × 3–4	Branched	Ipulet & Ryvarden 2005
ellipsospora	Annual	Whitish to pale yellowish brown	3–4	4–5.5 × 3–4	Unbranched	Gilbertson & Ryvarden 1987
koreana	Annual	Grayish orange	5–6	6–7 × 3.9–5.2	Rarely branched	Jang & al. 2015
luteola	Perennial	Buff-yellow	4–6	6–7 × 5–5.5	Frequently branched	Zhao & Cui 2013
mopanshanensis	Perennial	Cream, buff to straw	3–5	5.5–6.5 × 4–5	Unbranched	This study
rhizomorpha	Annual	Yellow-buff to yellowish orange	4–6	5.3–6.5 × 4.1–5.2	Branched	Cui & al. 2007
subacida	Perennial	Ivory to yellowish	5–6	4.5–6 × 3.5–4.5	Unbranched	Decock & Stalpers 2006

been described (Cui & Dai 2008; Cui & al. 2009, 2010, 2011; Du & Cui 2009; Li & Cui 2010; He & Li 2011; Jia & Cui 2011; Yu & al. 2013; Yang & He 2014; Chen & al. 2015). We anticipate that additional polypore taxa will be found in China after further investigation and molecular analysis.

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New records of *Bilimbia* and *Toninia* from China

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Abstract—As a result of our study on the lichen flora of Northwest China, one species of *Bilimbia* (*B. lobulata*) and three species of *Toninia* (*T. coelestina, T. gobica,* and *T. superioris*) are reported for the first time from China.

Keywords—Asia, biodiversity, *Lecanorales*, *Ramalinaceae,* taxonomy

Introduction

Bilimbia De Not. and *Toninia* A. Massal. belong to *Ramalinaceae* C. Agardh (*Lecanorales*), a widely distributed lichen family (Ekman 2001, Ekman & al. 2008).

Bilimbia is distinguished from *Bacidia*, *Biatora,* and *Mycobilimbia* by the stout paraphyses and ascospores often surrounded by a finely warted perispore (Smith & al. 2009, Veldkamp 2004.).

Toninia was described by Massalongo (1852) originally based on ascospore morphology as well as on characters of apothecia and thallus. Today it is additionally diagnosed by the asci and paraphyses. The asci are *Bacidia*-type, clavate. The paraphyses are usually straight and rarely branched (except at the tips), with apical cells that are distinctly swollen and usually capped with gelatinous pigment. Epithecial pigments that also characterize *Toninia* include grey (K+ violet, N+ violet), bright green (K–, N+ violet), olivaceous green (K+ violet/brown, N–), reddish brown (K+ red, N–), and dull brown (K–, N–) (Timdal 1991, 2002; Zahlbruckner 1890).

Here we report one species of *Bilimbia* (*B. lobulata*) and three species of *Toninia* (*T. coelestina, T. gobica,* and *T. superioris*) for the first time from China.

Materials & methods

The specimens studied are deposited in the Lichen Section, Botanical Herbarium, Shandong Normal University, Jinan, China (SDNU), and the Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences, Beijing, China (HMAS-L). The specimens were examined morphologically under an Olympus SZ stereo-microscope and Olympus CX21 polarizing microscope. Thalli and medullae were tested for identification with K (potassium hydroxide, 10% aqueous solution), C (sodium hypochlorite, saturated aqueous solution), I (potassium iodide, 10% aqueous solution), N (10% nitric acid), and P (saturated solution of *p*-phenylenediamine in 95% ethyl alcohol). Lichen substances were identified using standardized thin layer chromatography (TLC) techniques with system C (Orange & al. 2001). The lichens were digitally photographed under Olympus SZX16 and BX61 with DP72.

Taxonomic descriptions

Bilimbia lobulata (Sommerf.) Hafellner & Coppins, Lichenologist 36: 195 (2004) FIG. 1

THALLUS warted-granular to squamulose, squamules ≤0.6 mm wide, continuous, ±overlapping, yellowish white; APOTHECIA ≤1 mm diam., lecideine, black, sessile, flat to slightly convex, epruinose to faintly pruinose; PROPER EXCIPLE reddish brown (similar to hypothecium), K+ intensifying or reddish purple; EPIHYMENIUM ≤15 µm high, olive green, K–, N+ reddish; HYMENIUM 70–85 µm high, colourless to dull reddish brown; SUBHYMENIUM 25–40 µm high, usually colourless; PARAPHYSES conglutinated, simple or slightly branched, 2–3.5 µm diam. with apical cell distinctly swollen ≤5 µm diam.; ASCOSPORES medium fusiform, (0–)2–3-septate, 15–20 × 3–5 µm.

CHEMISTRY—Cortex and medulla K–, C–, KC–; Zeorin detected by TLC.

SPECIMENS EXAMINED: **CHINA. QINGHAI: Qilian,** Niuxinshan, alt. 3500 m, on soil, 11 Aug. 2007, 11 Aug. 2007, J.G. Liu 20071633 (SDNU); **SHANXI: Niingwu,** Luyashan, alt. 2500 m, on soil, 26 Aug. 2011, H.Y. Wang 20121675 (SDNU).

DISTRIBUTION—Europe, North America, Antarctica, Asia (Smith & al. 2009, Urbanavichus 2010). New to China.

COMMENTS—The Chinese material closely matches the previously published description by Hafellner & al. (2004). *Bilimbia lobulata* is

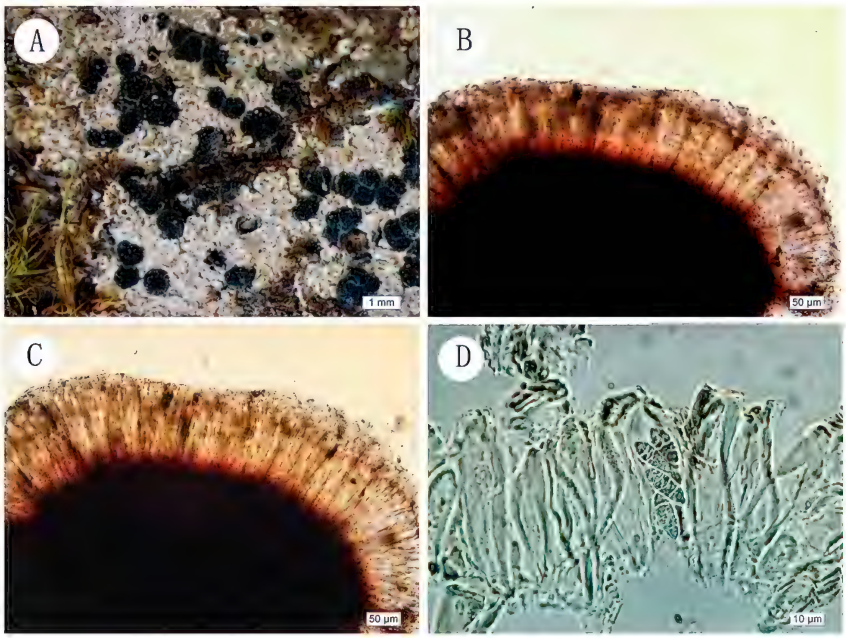

Fig. 1. *Bilimbia lobulata* (SDNU 20071633). A. Thallus and apothecia; B. Apothecium section; C. Apothecium section (showing epihymenium K+ reaction); D. Ascospores with three septa. Scale bars: A = 1 mm; B, C = 50 µm; D = 10 µm.

distinguished from *B. sabuletorum* (Schreb.) Arnold, which has a crustose thallus, and longer, 3–7(–9)-septate ascospores (Smith & al. 2009).

Toninia coelestina (Anzi) Vězda,
Čas. Slez. Mus., Ser. A, Hist. Nat. 10: 105 (1961) Fig. 2

Thallus crustose to subsquamulose, continuous to warty, granules present; upper side pale yellowish brown to greyish brown, epruinose, without pores and pseudocyphellae; Apothecia 0.75–1.5 mm diam., epruinose, when young flat and mostly marginate, when mature mostly weakly convex and immarginate; Proper exciple grayish black on the rim, dark brown in inner part, K–, N+ violet; Hypothecium dark brown; Hymenium 50–65 µm high; Epithecium dark olive green, K–, N+ violet; Paraphyses simple or slightly branched at the tip, 2–3.5 µm diam. with apical cell swelling ≤4.5 µm diam.; Ascospores narrowly ellipsoid to bacilliform, 3–7-septate, 17.5–37.5 × 2.5–3.5 µm.

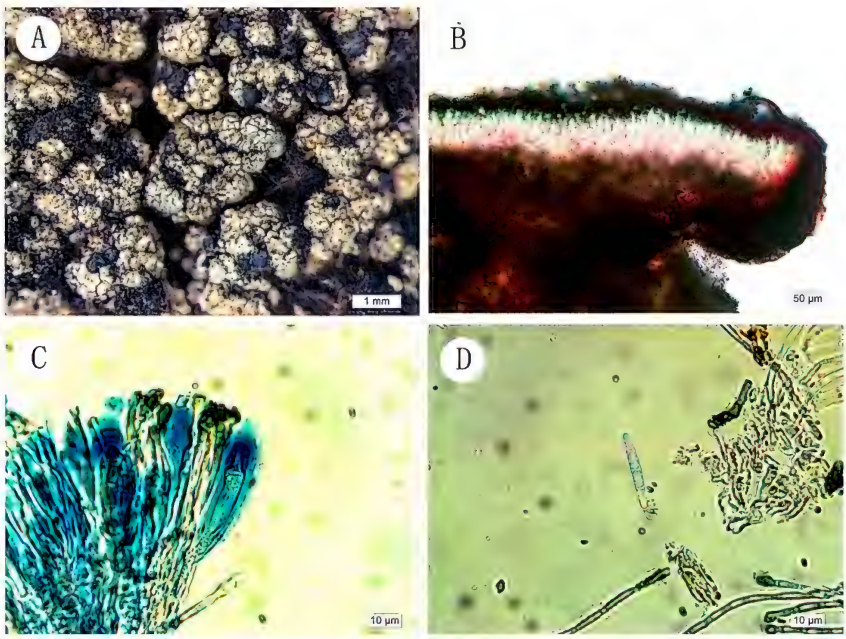

FIG. 2. *Toninia coelestina* (SDNU 20126519a). A. Thallus with apothecia; B. Apothecium section; C. Asci: Bacidia-type; D. Ascospore with three septa. Scale bars: A = 1 mm; B = 50 µm; C, D = 10 µm.

CHEMISTRY—Cortex and medulla K–, C–, KC–. Terpenoids detected by TLC.

SPECIMEN EXAMINED: **CHINA. XINJIANG: Tianshan,** Yihaobingchuan, alt. 2480 m, on soil, 26 Aug. 2011, L. Li 20126519a (SDNU).

DISTRIBUTION—Europe: Austria, Italy, Norway, Poland, Scotland, Slovakia (Flakus 2007, Timdal 1991, van den Boom & al. 1996, Vězda A. 1961). New to China.

COMMENTS—The Chinese material closely matches previously the published description by Vězda (1961). *Toninia coelestina* closely resembles *T. thiopsora* (Nyl.) H. Olivier, which differs by its 7-septate ascospores and its C+ orange thallus (Smith & al. 2009).

Toninia gobica N.S. Golubk., Bot. Zhurn. SSSR 58(6): 838 (1973) FIG. 3

THALLUS squamulose, squamules ≤3 mm diam., scattered to contiguous, slightly to strongly convex, weakly pruinose, dull yellow, without pseudo-

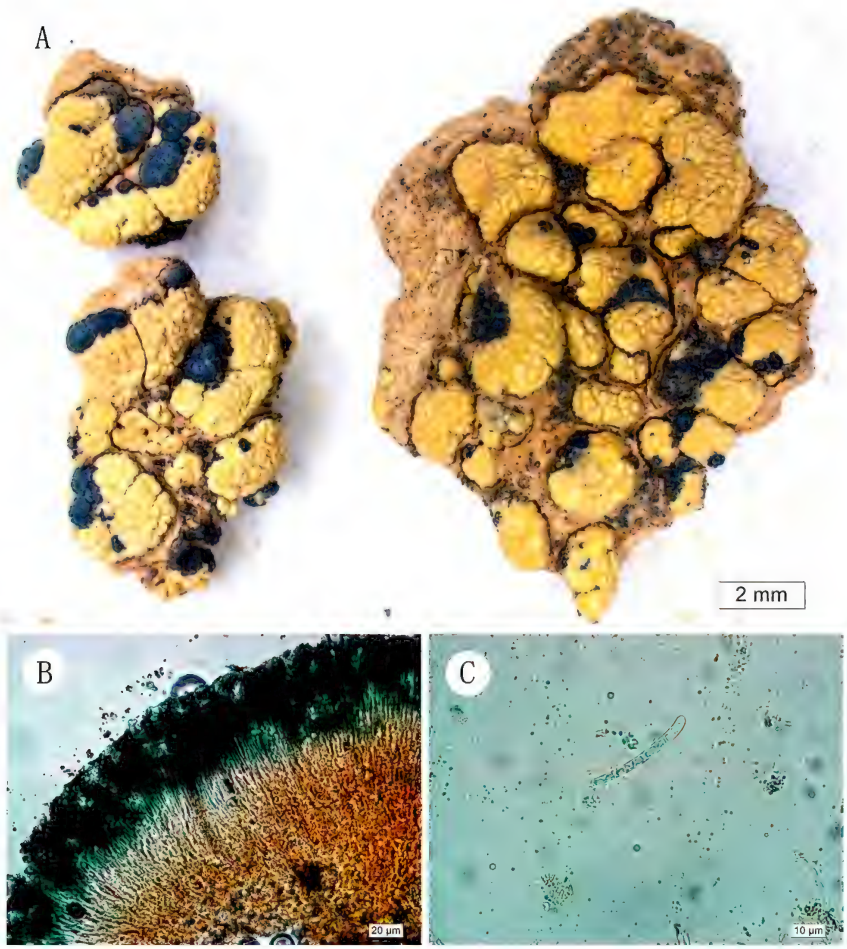

Fig. 3. *Toninia gobica* (HMAS-L 121615). A. Thalli with apothecia; B. Apothecium section; C. Ascospore with three septa. Scale bars: A = 2 mm; B = 20 µm; C = 10 µm.

cyphellae, mostly rimose on the surface; Apothecia ≤1 mm diam., flat to strongly convex, usually on the edge of thallus, epruinose to slightly pruinose; Proper exciple dark brown in inner part, K–, N–; Hypothecium dull yellowish brown or colourless; Hymenium 60–70 µm high; epithecium bright green, K–, N+ violet; Ascospores acicular, 3-septate, 30–45 × 3–5 µm.

Chemistry—Cortex and medulla K–, C–, KC–. Terpenoids detected by TLC.

Specimens examined: **CHINA. Ningxia: Zhongwei,** Shapotou, Cuiliugou, alt. 1200 m, on soil, 9 Apr. 2010, T. Zhang 121615 (HMAS-L); **Neimenggu: Wulatehouqi,** Huhebashige, alt. 1600 m, on rock, 19 Aug. 2011, H.Y. Wang 20122753 (SDNU).

Distribution—Mongolia (Golubkova 1973, Timdal 1991). New to China.

Comments—The Chinese material closely matches the type description by Golubk (1973). *Toninia gobica* and *T. lutosa* (Ach.) Timdal both have regular fissures on the thallus, but *T. lutosa* has deeper fissures and also differs by its dark reddish brown epithecium and shorter, K+ red, N–, (1–)3-septate ascospores (Timdal 1991).

Toninia superioris Timdal, Opera Bot. 110: 103 (1991) Fig. 4

≡ *Kiliasia superioris* (Timdal) Timdal, in Kistenich & al., Taxon 67(5): 893 (2018)

Thallus squamulose, squamules ≤1 mm diam., imbricate or contiguous, orbicular to irregular, flat to slightly convex, pruina present or absent, whitish grey, fissures and pseudocyphellae absent; Apothecia ≤1mm diam., flat to slightly convex, marginate or immarginate, faintly pruinose; Proper exciple grey on the rim, paler grey to colourless in the inner part, K+ violet, N+ violet; Hypothecium colourless to pale brown; Epithecium grey, K+ violet, N+ violet; Ascospores narrowly or broadly fusiform, mainly 3-septate, 12.5–20 × 3.5–5 μm.

Chemistry—Cortex and medulla K–, C–, KC–. Terpenoids detected by TLC.

Specimen examined: **CHINA. Neimenggu: Keqi,** Huangganglіang, alt. 2000 m, on soil, 13 Aug. 2011, H.Y. Wang 20117397 (SDNU).

Distribution—U.S.A.: Michigan (Timdal 1991). New to China.

Comments—The Chinese material closely matches the type description by Timdal (1991). *Toninia superioris* resembles *T. hosseusiana* Gyeln., which differs by its dark reddish brown epithecium and proper exciple (K+ red, N–), and its ≤3 mm diam. thalline squamules covered with farinose pruina (Gyelnik 1942, Timdal 1991).

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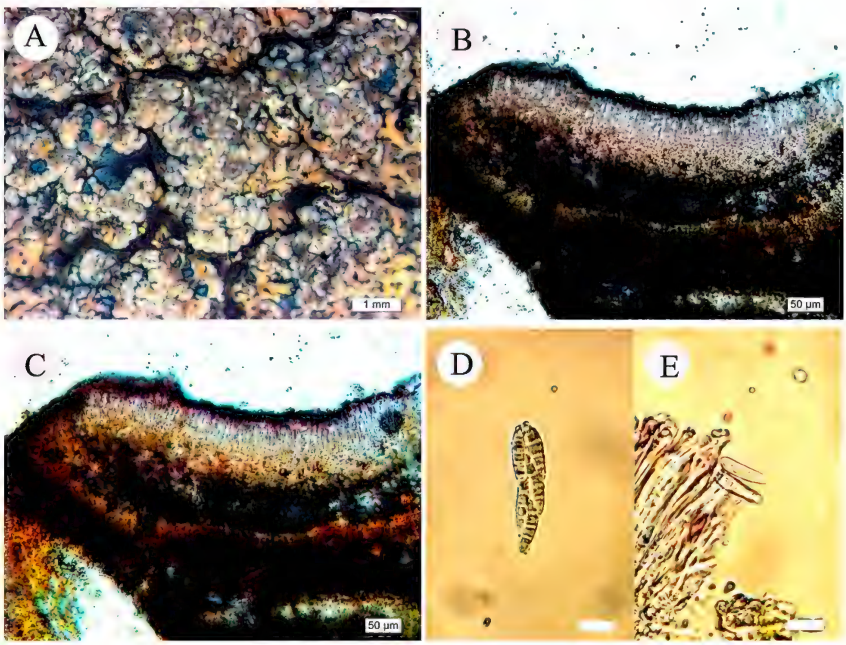

Fig. 4. *Toninia superioris* (SDNU 20117397). A. Thallus and apothecia; B. Apothecium section; C. Apothecium section (showing epihymenium K+ reaction); D, E. Ascospores with three septa. Scale bars: A = 500 µm; B, C = 20 µm; D, E = 10 µm.

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Anamylopsora altaica sp. nov. from Northwestern China

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Abstract—*Anamylopsora altaica*, collected from rocks in the Hot Spring Valley Forest Park in the Altay Mountains, Xinjiang, Northwestern China, is described as a new species, based on morphological and chemical characteristics, as well as ITS DNA sequence data. The new lichen species is characterized by its crowded, overlapping squamules with upturned margins, crowded globose apothecia with eight simple hyaline spores per ascus, and the presence of psoromic acid. A detailed description and colour photographs are provided.

Key words—*Anamylopsoraceae*, *Baeomycetaceae*, *Baeomycetales*

Introduction

The lichen biota of Northwestern China is rich, with more than 750 species belonging to c. 150 genera (Wei 1991, Abbas & Wu 1998, Abbas & al. 2001, Guo 2005). One lichen from temperate and tropical regions, *Anamylopsora pulcherrima* (Vain.) Timdal, type of the monotypic genus *Anamylopsora* Timdal (Huneck & Elix 1993, Lumbsch & al. 1995), has been collected in China from Gansu (Magnusson 1940, Timdal 1991, Wei 1991), Neimenggu (Magnusson 1942, Timdal 1991, Wei 1991) and Xizang (Obermayer 2004). *Anamylopsora pulcherrima* was originally described as *Lecidea pulcherrima* Vain. (Vainio 1888), subsequently combined as *Psora pulcherrima* (Vain.) Elenkin (Elenkin 1904), and finally transferred to *Anamylopsora* by Timdal (1991).

A comparison of anatomical, chemical, and ontogenetical characters initially supported *Anamylopsora* within a new family *Anamylopsoraceae*

Lumbsch & Lunke (*Agyriineae*, *Lecanorales;* Lumbsch & al. 1995), but more recent phylogenetic analyses place the genus in *Baeomycetaceae*, *Baeomycetales*. *Anamylopsora* specimens collected recently from northwestern China have been examined and are described here as a new species, *Anamylopsora altaica*.

Materials & methods

Specimens of the lichen *Anamylopsora* were collected by from rocks in the Hot Spring Valley Forest Park and in the Two-River Source Nature Reserve, Altay Mountains, Xinjiang, Northwestern China, and have been deposited in the Lichen Section of the Botanical Herbarium, Arid land Lichen Research Center of Western China, Xinjiang University, Urumqi, China (XJU).

Morphology

The specimens were examined using a Nikon Eclipse E200 stereo-microscope. Sections were cut by hand using a razor blade and were mounted and observed in water and iodine. The structure and hymenial characters were studied with a Zeiss Axioskop 2 plus light microscope and photographed using a Nikon Digital Camera D50. Chemical constituents were identified by colour spot tests and thin-layer chromatography using solvent system C (Orange & al. 2010).

DNA extraction, amplification, sequencing

Thallus fragments with ascomata were removed from the holotype and two other specimens for DNA extraction using the DNAsecure Plant DNA Kit following the manufacturer's protocol. The nrITS (ITS1+5.8S+ITS2) region was amplified in a polymerase chain reaction according to Han & al. (2013) as modified in Abbas & al. (2014) using the primers ITS1F (Gardes & Bruns 1993) with ITS4 (White & al. 1990). The DNA was amplified in a 30 µL volume containing 0.75 units of TransStart Taq Polymerase, 3.5 µL buffer, 0.5 µl of a 5 µM primer solution, 2 µL each per 2.5 mM dNTP solution, and 1 µL of genomic DNA. The PCR mixture was cycled at 95°C for 5 min; then 35 cycles at 94°C for 30 s, 55°C for 45 s, and 72°C for 1 min; with a final extension of 72°C for 10 min. PCR products were screened on 1% agarose gels stained with ethidium bromide and sequenced by Shenggong Inc. in Shanghai. Newly obtained sequences were submitted to GenBank.

We aligned ITS sequences from our three specimens and the 17 GenBank representatives using ClustalW and Muscle implemented in MEGA7 (Kumar & al. 2016). The final matrix, submitted to TreeBase, is available by request from the corresponding authors.

The evolutionary history was inferred by using the Neighbour-joining (NJ) method implemented in MEGA7 (Saitou & Nei 1987, Tamura & al. 2004, Kumar & al. 2016). Bootstrap replication was set to 1000, and the evolutionary distances were computed using the Maximum Composite Likelihood method and were in units of the number of base substitutions per site. Rate variation among sites was modeled with a gamma distribution (shape parameter = 5). The Minimum Evolution (ME) tree was searched

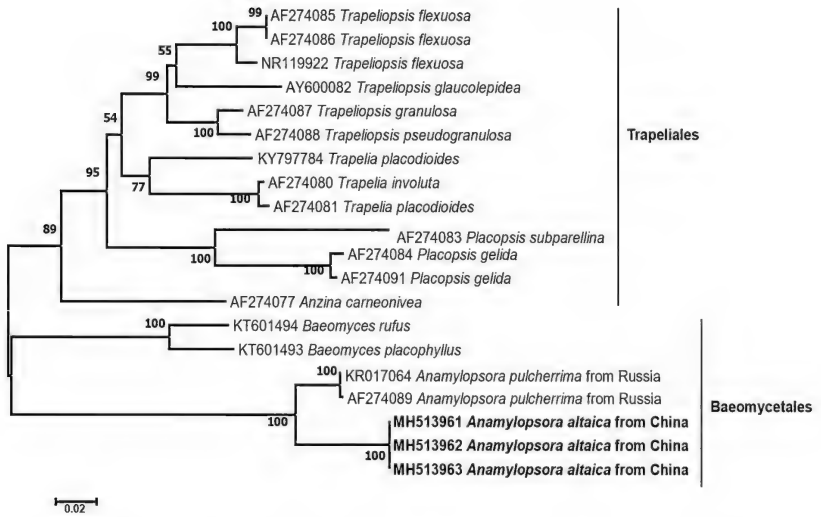

FIG.1 Neighbour-joining (NJ) phylogenetic tree of ITS sequences for *Anamylopsora altaica* and similar species retrieved from GenBank. Numbers above branches indicate values >50% from 1000 bootstrap replicates of NJ analyses.

using the Close-Neighbor-Interchange (CNI) algorithm at a search level of 1. The initial tree was generated by the Neighbor-joining algorithm. The gaps were removed for each sequence pair.

ITS sequence analysis and phylogeny

The entire ITS region was successfully sequenced for the holotype specimen and two additional specimens. A Blast search was conducted, and GenBank sequences from taxa sharing the most similarity with our new sequences were selected (Timdal 1991, Lumbsch & al. 1995). Partial sequences of the 3′ end in SSU region and the 5′ end in LSU region were included in the data submitted to GenBank.

The final nrITS alignment included 20 sequences representing 13 taxa and comprised 513 sites, of which 441 were constant, 18 were parsimony-uninformative, and 54 were parsimony-informative. There were no ambiguously aligned regions.

ITS sequences support our specimens in *Anamylopsora* with close affinities to the existing *A. pulcherrima* sequences in GenBank (91% with KR017064; 90% with AF274089). The evolutionary history was inferred as the NJ tree. The

phylogeny clearly shows the relationship of the new species with closely related species (Fig. 1). *Anamylopsora* and *Baeomyces* cluster together in a monophyletic group within *Baeomycetales*, which is a sister group to the *Trapeliales*.

Taxonomy

Anamylopsora altaica Ahat, A. Abbas, S.Y. Guo & Tumur, **sp. nov.** Fig. 2

FungalName FN570571

Differs from *Anamylopsora pulcherrima* by its overlapping squamules, its crowded globulose apothecia concentrated along the squamule margins, and the presence of psoromic acid and absence of alectorialic acid.

Type: China. Xinjiang: Altay Mountains, Hot Spring Valley Forest Park, 47°33′52″N 88°41′29″E, alt. 1030 m, 17 May 2014, A. Tumur & A. Abbas Altay-20140041 (**Holotype**, XJU; GenBank MH513961; **Isotype**, HMAS-L).

Etymology: The new species is named after the Altay Mountains, where the holotype was collected.

Thallus irregularly squamulose, usually appressed on siliceous rocks; squamules ≤1(–2.5) mm diam., intensively overlapping, without soredia or isidia, pale-green to light yellow-green, with or without a light frosting of pruina on the upper surface; thallus margin entire to subentire, usually upturned; upper surface white to whitish-grey pruinose; lower surface white to dirty white, without rhizines; upper cortex 55–95 µm thick, brown to light-brown; algal layer 135–195 µm thick, continuous, algal cells 8–12 µm diam., photobiont *Trebouxia* sp.; medulla 190–280 µm thick; lower cortex paraplectenchymatous, 30–65 µm thick.

Apothecia lecideine, ≤1(–1.5) mm diam.; often >10 globose apothecia in clusters ≤12 mm diam. attached to the squamule margins; disc brown to dark brown, dull, epruinose; epihymenium faint yellow to light brown, 25–30 µm high; hymenium 95–115 µm high. Paraphyses simple or sparingly branched. Hypothallus colourless, 70–115 µm high. Asci narrowly clavate to subcylindrical, lacking an ocular chamber, inamyloid, 8-spored, 50–70 × 12–16 µm. Ascospore hyaline, simple, ellipsoid, thin-walled, 9–12 × 5–8 µm, usually with 1–3 oil drop(s) and a warty surface. Pycnidia occurring at the squamule margins, rod-shaped, ≤0.4 mm diam., dark brown to black. Conidia hyaline narrowly ellipsoid to shortly bacilliform, 3 × 1 µm.

Color tests—Thallus cortex PD+ orange, K+ yellow, C–, KC–, UV–. Thallus medulla PD–, K–, C–, KC–. Apothecial disks I+ blue, K–, C–, UV–.

Secondary metabolites—Only psoromic acid detected by TLC.

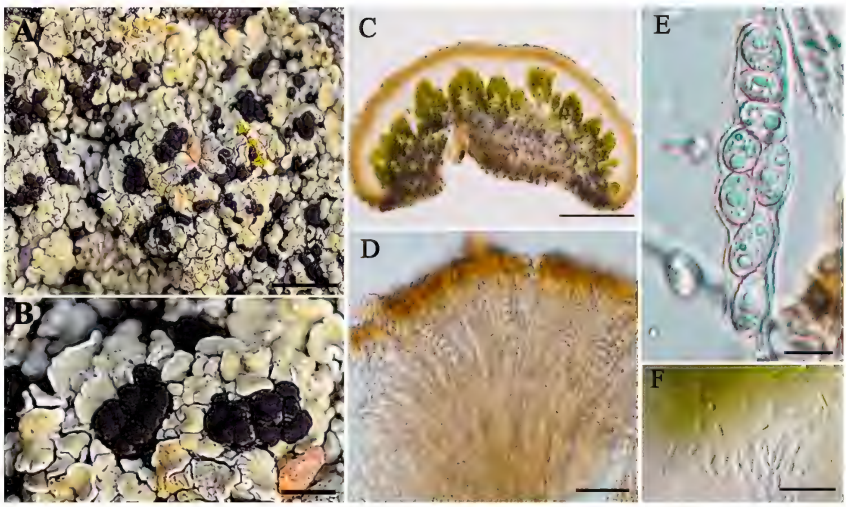

Fig. 2 *Anamylopsora altaica* (Holotype, XJU Altay-20140041). A. General habit; B. Apothecia; C. Interrupted algal layer in thin section of the thallus; D. Section of apothecium; E. Ascus and spores; F. Conidia. Scale bars: A = 10 mm; B = 1 mm; C = 200 µm; D = 50 µm; E = 20 µm; F = 5 µm.

Ecology—*Anamylopsora altaica* grows at altitudes of c. 900–1200 m in montane forests, on semi-shaded granite rocks, in association with *Aspicilia concorta,* and *Acarospora* sp. The species is known only from Xinjiang, Northwestern China; although rare in the type locality, it may occur in other regions in central Asia.

Additional specimens examined—**CHINA. Xinjiang: Altay Mountains**, Hot Spring Valley Forest Park, 47°50′23″N 88°42′51″E, alt. 960 m, 26 May 2014, Anwar Tumur & Abdulla Abbas 20140032 (XJU-NALH, GenBank MH513962); 47°03′41″N 88°67′06″E, alt. 1022 m, Anwar Tumur & Abdulla Abbas 20140040 (XJU-NALH); Two-River Source Nature Reserve, 47°45′09″N 88°34′48″E, alt. 1187 m, 20 July 2015, Anwar Tumur & Abdulla Abbas 20150068 (XJU-NALH; GenBank MH513963).

Comments—*Anamylopsora altaica* and *A. pulcherrima* are distinguished by thallus color, apothecial characters, secondary substances, and substrate. *Anamylopsora pulcherrima* usually has yellow lobes and black apothecia, with squamules having a strongly fissured upper side, a purplish-red lustrous thallus with a lacinulate appearance, and produces alectorialic acid; additionally, *A. pulcherrima* grows at higher altitudes (c. 2700–3000 m), on calciferous stone or calcareous soil in association with *Phycia kansuensis, Psorotichia nigra,* and several other small lichens (Timdal 1991, Lumbsch & al.1995). *Lecidea hedinii*

and *L. undulata,* which were synonymised with *Anamylopsora pulcherrima* by Timdal (1991), also resemble *A. altaica*, but differ in their 'flavescenti-testaceus' thallus colour and areolate shape, their K+ (orange) cortex, and their infrequent, smaller (0.3–0.5 mm), dirty reddish apothecia (Magnusson 1942).

Anamylopsora and *Baeomyces* both exhibit a similar ascoma ontogeny and the same type of conidiophores, although these similarities may well result from convergent evolution (Lumbsch & Huhndorf 2010). However, although closely related by molecular phylogeny, they differ in the ascus type. *Anamylopsora altaica* resembles some species of *Trapeliopsis* and *Trapelia*, e.g., *Trapelia placodioides*, but has slightly smaller lobes [<3 mm] and a smooth upper surface.

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Four *Pyrenula* species new to China

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Abstract—*Pyrenula brunnea*, *P. punctella, P. subducta,* and *P. submastophora* are reported for the first time from China. This increases the number of *Pyrenula* species known from China to 46. Descriptions and distribution of the four species are given.

Key words—Asia, lichen-forming fungi, *Pyrenulaceae*, taxonomy

Introduction

Pyrenula Ach. (*Pyrenulaceae*, *Eurotiomycetes*) comprises crustose lichens typically growing on smooth, shaded bark (Aptroot 2012) in the tropics and subtropics (Mendonça & al. 2016). It is characterized by a corticate (occasionally ecorticate) UV± yellow thallus with or without pseudocyphellae and with perithecioid ascomata, an occasionally inspersed hamathecium with unbranched filaments, and distoseptate, bacillar or (sub)muriform ascospores that are brown when mature with rounded, diamond-shaped, or elongated lumina and with or without orange oil when over-mature.

In his world key to *Pyrenula* species, Aptroot (2012) accepted 169 species out of the c. 745 named taxa in the genus. With many new species of *Pyrenula*

[#] Jie-Meng Fu & André Aptrootcontributed equally to this research.

since described, the genus currently comprises c. 226 species worldwide (Ingle & al. 2018), of which 42 are known from China (Wei 1991, Aptroot 2003, Aptroot & Seaward 1999, Aptroot & Sipman 2001, Fu & al. 2018, Seaward & Aptroot 2005, Wang & al. 2018).

The purpose of this paper is to contribute to the knowledge of *Pyrenula* in China and to provide data for the Lichen Flora of China (in prep.). Here we report four species from China for the first time—*Pyrenula brunnea*, *P. punctella*, *P. subducta,* and *P. submastophora*—increasing the number of species known from China to 46.

The specimens studied are from Guizhou province, located in southern China on the Yunnan–Guizhou plateau (24°37′–29°13′N 103°36′–109°35′E). The landscape belongs to the plateau mountain region, with an average elevation of about 1100 m. Guizhou has a subtropical humid monsoon climate (rainy and hot at the same time) with the average temperature usually 22–25°C during the warmest month (July); the annual precipitation averages 1200 mm (rain mostly occurring during June–September).

Materials & methods

The specimens studied are preserved in the Lichen Section of the Herbarium, College of Life Sciences, Shandong Normal University, Jinan, China (SDNU). Their morphology was examined under a COIC XTL7045B2 stereo-microscope and Olympus CX41compound microscope. Unless otherwise indicated, sections were mounted and measured in tap water or enhanced with KOH. The lichen substances were studied by standardized thin layer chromatography (TLC) using solvent system C (Orange & al. 2010). Photos were taken with Olympus SZX16 and BX61 with DP72.

Taxonomy

Pyrenula brunnea Fée, Essai Crypt. Écorc. 2: 81 (1837) Fig. 1a–d

Morphology—Thallus corticate, brownish, without pseudocyphellae, UV–. Perithecia simple, solitary, often partly covered by the thallus, 0.4–0.5 mm diam. Ostioles black, apical. Perithecial wall ≤150 µm thick. Hamathecium not inspersed with oil droplets. Ascospores 8/ascus, pale brown, 3-septate, with rounded ends, 12.5–15 × 7.5 µm, lumina in a straight line, somewhat rounded, end lumina with a thick apical endospore layer, over-mature ascospores shriveled, without red-orange oil.

Chemistry—No chemical substances detected by TLC.

Specimen examined: **CHINA. Guizhou, Tongren**, Jiangkou, Mt. Fanjing, alt. 1300 m, on bark, 1 Nov. 2009, Zhao-Jie Ren 20101318 (SDNU).

Distribution—Pantropical (Aptroot 2012). New to China.

Comments—*Pyrenula brunnea* is similar to *P. aspistea* (Ach.) Ach., which has narrower ascospores (4–6 µm; Aptroot 2012). Our material fits the description of *P. brunnea* specimens from northeast India quite well (Upreti 1991).

Pyrenula punctella (Nyl.) Trevis., Conspect. Verruc.: 13 (1860) Fig. 1E–H

Morphology —Thallus corticate, yellowish, with white pseudocyphellae, UV–. Perithecia solitary, aggregated only by chance when crowded, 0.3–0.4 mm diam. Ostioles pale, apical. Perithecial wall ≤140 µm thick. Hamathecium not inspersed with oil droplets. Ascospores 8/ascus, brown, 3-septate, fusiform with pointed ends, 37.5–40 × 12.5–15 µm, lumina angular to usually somewhat rounded, end lumina with a thick apical endospore layer, overmature spores lacking orange oil.

Chemistry —No chemical substances detected by TLC.

Specimen examined: **CHINA. Guizhou, Libo**, Maolan protection zone, alt. 500 m, on bark, 2 Nov. 2009, Hai-Ying Wang 20102422 (SDNU).

Distribution—Temperate America, extending to Japan (Aptroot 2012). New to China.

Comments—*Pyrenula punctella* is similar to *P. mastophora* (Nyl.) Müll. Arg., which differs by lacking pseudocyphellae and having central lumina that are much wider than long (Aptroot 2012). Our material closely fits the protologue description of the *P.* (≡ *Verrucaria*) *punctella* holotype specimen (Nylander 1858).

Pyrenula subducta (Nyl.) Müll. Arg., Flora 67: 666 (1884) Fig. 1I–L

Morphology—Thallus corticate, yellowish brown, UV–. Perithecia simple, only aggregated by chance when crowded, often largely covered by thallus, 0.4–0.6 mm diam. Ostioles brown, apical. Perithecial wall ≤150 µm thick. Hamathecium not inspersed with oil droplets. Ascospores 8/ascus, uniseriate, brown, 3-septate, with rounded or pointed ends, 40–42.5(–45) × 15–17.5 µm, lumina in a straight line and somewhat rounded, end lumina with an apical endospore layer, over-mature ascospores without orange oil.

Chemistry—No chemical substances detected by TLC.

Specimens examined: **CHINA. Guizhou, Tongren**, Jiangkou, Mt. Fanjing, alt. 2300 m, on bark, 29 Mar. 2011, Xing-Ran Kou 20111283 (SDNU), Yu-Liang Chen 20111082 (SDNU). **Libo**, Maolan protection zone, alt. 500 m, on bark, 2 Nov. 2009, Yu-Liang Chen 20102362 (SDNU), Hai-Ying Wang 20102367 & 20102425 (SDNU); alt. 350 m, on bark, 2 Nov. 2009, Dai-Feng Jiang 20102432 (SDNU).

Distribution—Neotropical (Aptroot 2012). New to China.

Comments—*Pyrenula subducta* is similar to *P. caryae* R.C. Harris, which differs by the presence of black granules at the ascospore tips (Aptroot 2012). Our material fits the description of India collections of *P. subducta* quite well, but the Indian material has a brown to reddish-brown thallus (Ingle & al. 2018).

Pyrenula submastophora Ajay Singh & Upreti,
Geophytology 17(1): 85 (1987) Fig. 1M–P

Morphology—Thallus corticate, brownish, without pseudocyphellae, UV–. Perithecia simple, subglobose, erumpent, 0.4–0.6 mm diam. Ostioles black, apical. Perithecial wall ≤160 µm thick. Hamathecium not inspersed with oil droplets, filaments unbranched. Ascospores 8/ascus, uniserial, grey-brown, 3-septate, fusiform with rounded ends, 21–23 × 7.5 µm, end lumina with a thick apical endospore layer. Over-mature spores lacking orange oil.

Chemistry—No chemical substances detected by TLC.

Specimen examined: **China. Guizhou, Libo**, Maolan protection zone, alt. 500 m, on bark, 2 Nov. 2009, Hai-Ying Wang 20102312 (SDNU).

Distribution—Eastern palaeotropical India (Aptroot 2012). New to China.

Comments—*Pyrenula submastophora* is similar to *P. acutispora* Kalb & Hafellner, which differs by its ascospores having at least one pointed end (Aptroot 2012). Our specimen fits the description of Indian collections of *P. submastophora* (including the holotype), but the Indian material has larger perithecia (0.8–1.2 mm diam.; Upreti 1992).

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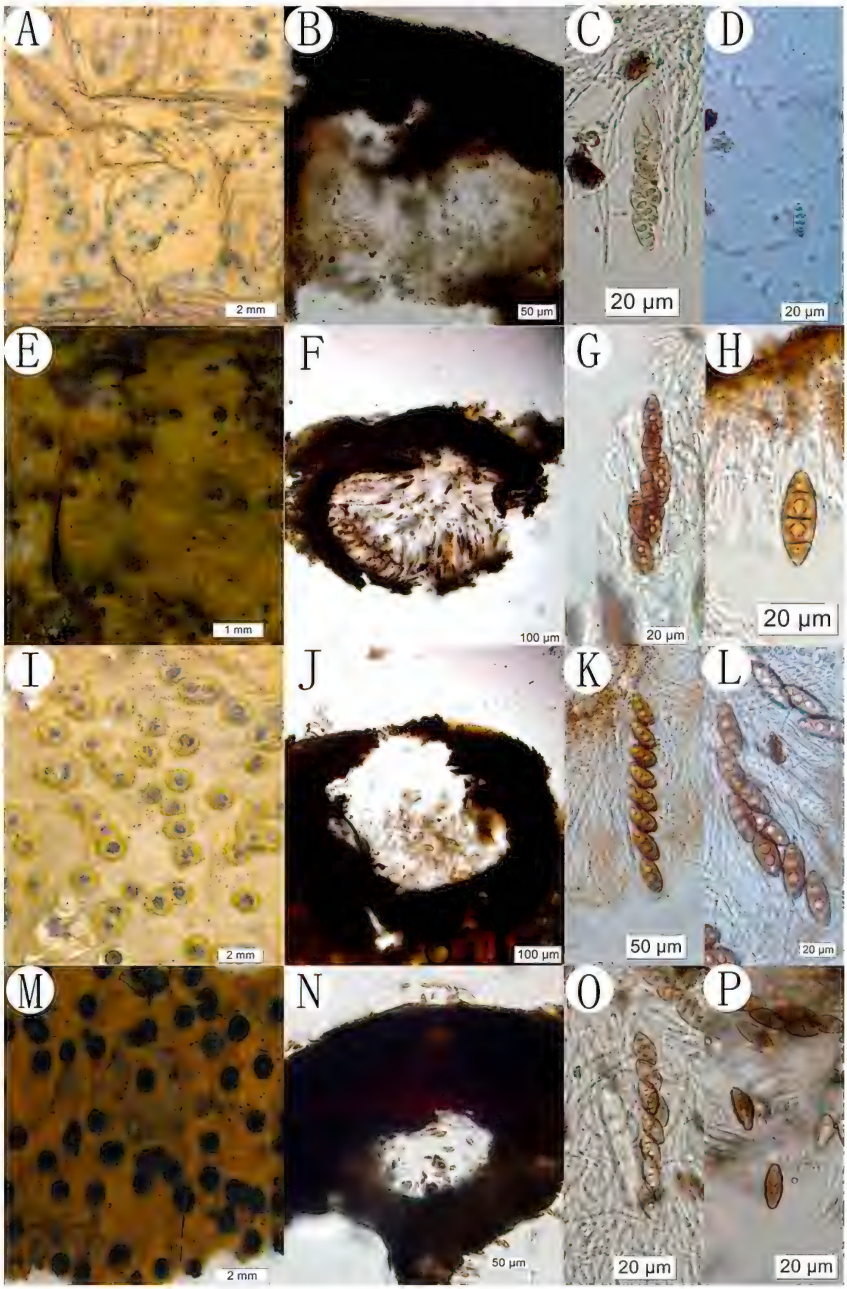
Fig. 1. ***Pyrenula brunnea*** (Ren 20101318, SDNU). A. thallus with ascomata; B. transverse section through ascoma; C. ascus; D. ascospores. ***Pyrenula punctella*** (Wang 20102422, SDNU). E. thallus with ascomata; F: transverse section through ascoma. G: ascus. H: ascospores. ***Pyrenula subducta*** (Kou 20111283, SDNU). I. thallus with ascomata; J. transverse section through ascoma; K. ascus with 8 ascospores; L. ascospores. ***Pyrenula submastophora*** (Wang 20102312, SDNU). M. thallus with ascomata; N. transverse section through ascoma; O. ascus with 8 ascospores; P. ascospores. Scale bars: E = 1 mm; A, I, M = 2 mm; C, D, G, H, L, O, P = 20 µm; B, K, N = 50 µm; F, J = 100 µm.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Spadicoides matsushimae sp. nov., and *Anisospadicoides* gen. nov. for two atypical *Spadicoides* species

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Abstract—*Anisospadicoides* is proposed as a new genus for two species of *Spadicoides*, *S. macrocontinua* and *S. macroobovata*, that have polytretic and blastic conidial ontogeny on the apical conidiogenous cells. A new species, *Spadicoides matsushimae*, distinguished by broadly fusiform to navicular, mostly 2-septate, brown to dark brown conidia, is also described and illustrated.

Key words—asexual *Ascomycota*, *Helminthosphaeriaceae*, hyphomycetes, systematics

Introduction

Spadicoides S. Hughes, typified by *S. bina* (Corda) S. Hughes, is distinguished by macronematous, mononematous, and generally unbranched erect conidiophores. Conidiogenous cells are polytretic, integrated, terminal and intercalary, determinate, with conidiogenous loci

at the apex and laterally below. The conidia are solitary, variously shaped (ellipsoidal, oblong, obovoid, obclavate, globose, clavate, or cuneate), unicellular or multicellular, euseptate, smooth or verruculose, subhyaline to brown or black, and dry (Ellis 1971, Hughes 1958, Ma & al. 2016, Xia & al. 2013, Whitton & al. 2012).

Two *Spadicoides* species, *S. macrocontinua* and *S. macroobovata*, have an unusual combination of tretic and holoblastic conidial development on the apical conidiogenous cells (Matsushima 1993, 1995). Conidial ontogeny and conidiogenous events have been considered the fundamental criteria for asexual fungal taxonomy and generic delimitation (Kendrick 2017, Seifert & al. 2011). Consequently, we propose the new genus *Anisospadicoides* to accommodate two atypical *Spadicoides* species.

In 1993, Matsushima published a description and illustrations of a conspicuous fungus found on rotten petiole of a palm, but he did not provide a species epithet for it, merely calling it "*Spadicoides* sp." This fungus is formally named here as a new species, *S. matsushimae*.

Taxonomy

Anisospadicoides R.F. Castañeda, Qiao & Z.F. Yu, **gen. nov.** FIG. 1

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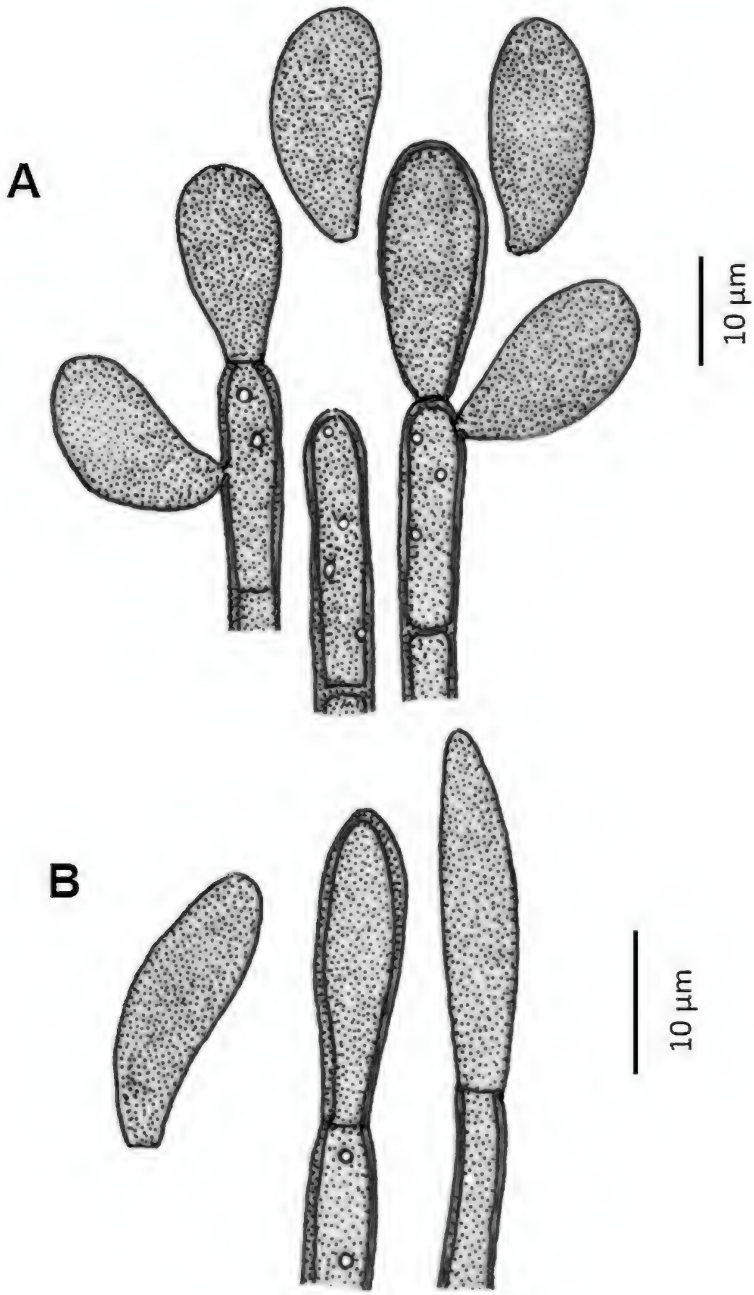
Differs from *Spadicoides* species by its holoblastic, mostly monoblastic conidial ontogeny, and production of conidia on the apical conidiogenous cells beside or near the tretic loci.

Type species: *Spadicoides macrocontinua* Matsush. [≡ *Anisospadicoides macrocontinua* (Matsush.) R.F. Castañeda & al.]

Etymology: Greek, *aniso-* meaning unequal, uneven, or dissimilar + Latin, *-spadicoides*, referring to the genus *Spadicoides*.

Colonies on CMA medium felted or hairy, brown to dark brown. Conidiophores macronematous, mononematous, unbranched, erect, straight, cylindrical, septate, smooth, brown to dark brown. Conidiogenous cells biontogenous, sometimes on the same cell: i) polytretic, integrated, mostly intercalary, cylindrical, sometimes terminal with subapical tretic loci and apical blastic loci; ii) monoblastic, integrated, terminal, sometimes with several tretic loci near below the blastic locus on the same cell.

FIG. 1. *Anisospadicoides macrocontinua* (holotype, MFC OP-302): A. Conidiogenous cells with apical conidia originated by holoblastic mode and subapical conidia borne from tretic loci; B. Conidiogenous cells with apical conidia originated by holoblastic mode and subapical tretic loci.


A
10 µm
B
10 µm

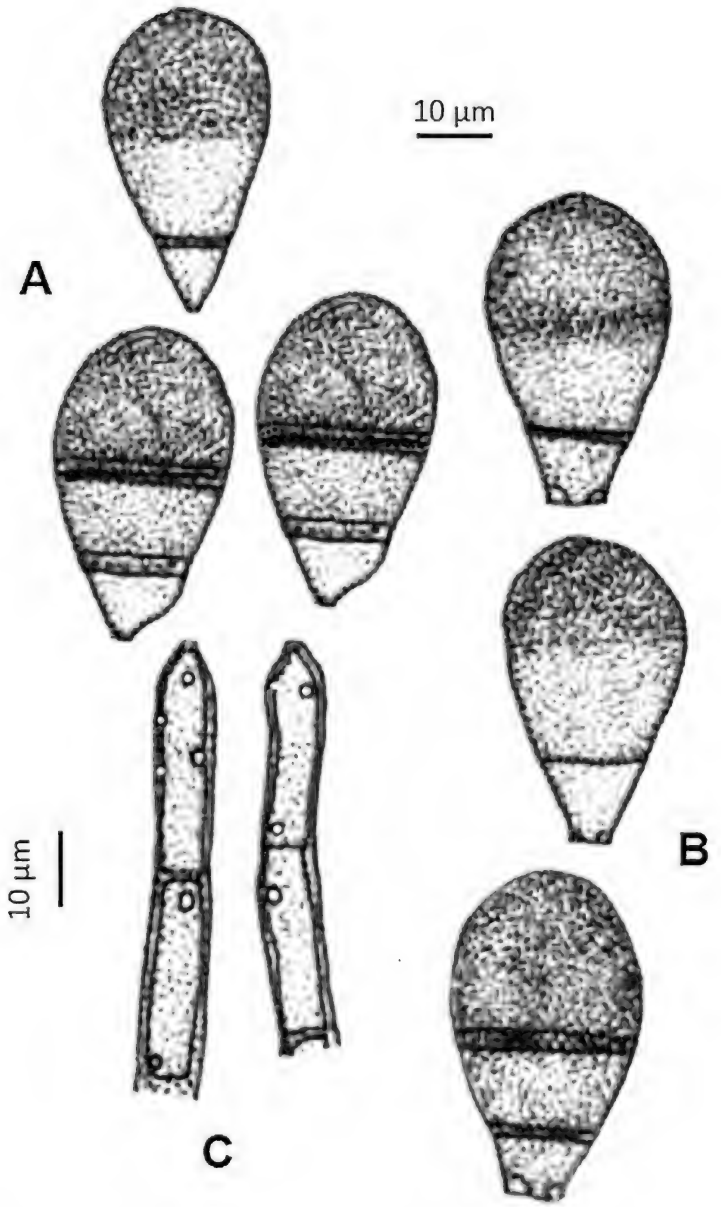


Fig. 2. *Anisospadicoides macroobovata* (holotype, MFC 4P-562): A. Conidia produced after holoblastic mode on the apical loci; B. Conidia produced after enteroblastic mode on the subapical and intercalary loci; C. Conidiogenous cells with apical blastic loci and subapical and intercalary tretic loci.

Conidia solitary, dimorphic: i) obovoid, subpyriform, truncate at the base, acropleurogenous, mostly pleurogenous, unicellular or septate, smooth, brown to dark brown or black, dry, borne on tretic conidiogenous loci; ii) obovoid, broadly subfusiform, to subclavate, attenuate or slightly fimbriate towards the truncate base, acrogenous, unicellular or septate, euseptate, smooth, brown to dark brown or black, dry, borne on blastic conidiogenous loci.

Anisospadicoides macrocontinua (Matsush.) R.F. Castañeda, Qiao & Z.F. Yu, **comb. nov.** Fig. 1

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≡ *Spadicoides macrocontinua* Matsush., Matsush. Mycol. Mem.7: 67 (1993).

Anisospadicoides macroobovata (Matsush.) Qiao, Z.F. Yu & R.F. Castañeda, **comb. nov.** Fig. 2

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≡ *Spadicoides macroobovata* Matsush., Matsush. Mycol. Mem. 8: 36 (1995).

Spadicoides matsushimae R.F. Castañeda & D.W. Li, **sp. nov.** Fig. 3

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Differs from *Spadicoides curvularioides* by its broadly fusiform, smaller, 2-septate, brown conidia.

Type: Peru, Rio Sinchicuy, 14°36′N 90°38′W, on decaying petiole of an unidentified palm, June 1991, coll. T. Matsushima (**Holotype**, MFC 1P-294).

Etymology: Latin, *matsushimae*, in reference to Takashi Matsushima, collector of the holotype specimen.

Conidiophores on the natural substratum macronematous, mononematous, unbranched, erect, straight, rigid, septate, brown, smooth, 50–160 µm long, 4.5–6 µm wide at the base, Conidiogenous cells polytretic, integrated, terminal and intercalary, determinate, brown. Conidia solitary, acropleurogenous, broadly fusiform to broadly navicular, conical-truncate at the base, rounded at the apex, (1–) 2-septate, smooth, 15–19 × 7–9 µm, with central cell brown to dark brown and larger than pale brown end cells.

Notes: There are 58 previously described species of *Spadicoides* (Index Fungorum 2018), of which only 42 were accepted by Goh & Hyde (1996), Kuthubutheen & Nawawi (1991), Ma & al. (2014, 2016), Whitton & al. (2012), and Xia & al. (2013). Ma & al. (2016) provided a comparative table of *Spadicoides* spp. and a key for their identification. Among the recognized *Spadicoides* species, only *S. curvularioides* B. Sutton & Hodges is superficially similar to *S. matsushimae* in producing more or less fusiform or navicular

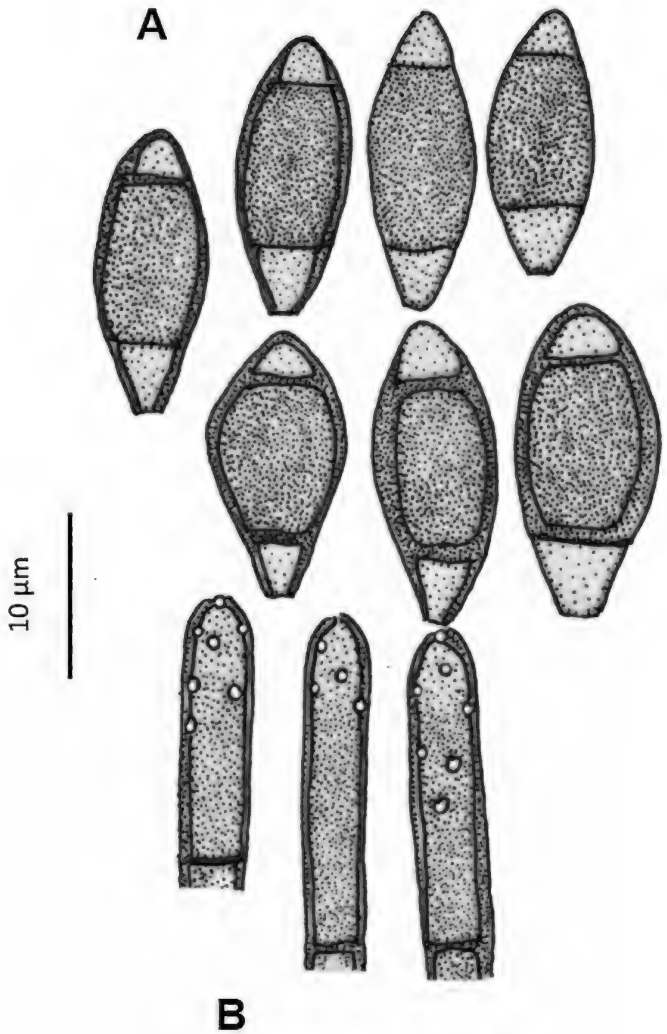

FIG. 3. *Spadicoides matsushimae* (holotype, MFC 1P-294):
A. Conidia; B. Conidiogenous cells and conidiogenous loci.

conidia, but *S. curvularioides* has pale brown conidia that are paler at the ends, 3-septate, longer (22–33.5 µm), and verruculose (Sutton & Hodges 1978).

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New records of *Hymenoscyphus, Parascutellinia,* and *Scutellinia* for Turkey

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Abstract—Three ascomycetous macrofungi—*Hymenoscyphus kathiae, Parascutellinia violacea,* and *Scutellinia crinita*—are recorded for the first time from Turkey, with *P. violacea* serving also the first record of the genus for the country. The species are described briefly and accompanied by photographs illustrating their macro- and micro-morphologies.

Key words—biodiversity, *Helotiaceae, Pyronemataceae,* Siirt, Van

Introduction

Since studies on Turkish macromycota started in the second quarter of the 20th century, almost 2500 species have been reported. Considering the 15,000 macrofungi reported from Europe (Lukić 2009), it can easily be said that there is still much to be done.

This study aims to identify new records for the mycobiota of Turkey. During routine field studies some ascomycete samples were collected and identified as *Hymenoscyphus kathiae (Helotiaceae), Parascutellinia violacea (Pyronemataceae),* and *Scutellinia crinita (Pyronemataceae).* Among the 220 ascomycete species from Turkey covered by current checklists (Sesli & Denchev 2014, Solak & al. 2015) and recent publications on Turkish *Ascomycota* (Kaya & Uzun 2015, 2018; Acar & Uzun 2016; Kaya & al. 2016, 2018; Akçay & Uzun 2016; Doğan & al. 2016; Keleş & Oruç 2017; Uzun & al. 2017a,b, 2018a,b; Işık & Türkekul 2018), these three species are not cited and represent new records for the country.

Materials & methods

Fungal specimens were collected from Baykan (Siirt) and from Gevaş and Gürpınar (Van) districts during 2012–2018. The fungi were photographed in their natural habitats and their ecological and morphological characteristics noted. Specimen samples were mounted in Congo red or Melzer's reagent and examined microscopically using a Leica DM500 light microscope. The fungi were identified after consulting Svrček (1975), Schumacher (1990), Korf (1999), Garcia & Van Vooren (2005), Medardi (2006), and Van Vooren & Hairaud (2009). The collections are kept in the fungarium of Yüzüncü Yıl University, Van, Turkey (VANF).

Taxonomy

Hymenoscyphus kathiae (Korf) Baral, Fl. Mediterr. 15: 66 (2005) Fig. 1

Apothecia 1–3 mm diam., subsessile to shortly stipitate, cupuliform, then more or less plane, margin smooth and glabrous. Hymenium smooth, pale yellow to golden yellow, outer surface almost concolorous with the hymenium or lighter. Stipe noticeably short, broad, yellowish white. Asci 90–110 × 7–10 µm, cylindrical, slightly attenuated at base and arising from croziers, generally 8-spored, some with fewer spores. Ascospores 9–14(–16) × 4–5 µm, ellipsoid, hyaline, smooth, some septate when mature, with two large or small guttules, uniseriate. Paraphyses cylindrical, rarely septate, hyaline, generally filled with yellowish guttules.

Specimen examined—**TURKEY, Siirt,** Baykan, central district, on wood remnants, 38°09'37"N 41°47'17"E, 769 m, 17.11.2012, A.K. 1877 (VANF).

Comments—*Hymenoscyphus kathiae* is macroscopically similar to *H. imberbis,* which differs in its ascospores with two large lipid droplets at the poles (Dimitrova & Baral 2005). In general, the morphological characteristics of our Turkish material agree with the descriptions by Dimitrova & Baral (2005) and Van Vooren & Hairaud (2009). This species is a new record for Turkey.

Parascutellinia violacea (Velen.) Svrček, Česká Mykol. 29: 129 (1975) Fig. 2

Apothecia 3–6 mm diam., violet in colour, usually found in small groups; surface elliptical, smooth. Hymenium carmine red, with some violet tones. Asci 260–320 × 16–17 µm, cylindrical, operculate, inamyloid. Ascospores 24–29 × 12–14 µm, hyaline, elliptical, thick-walled, with one large guttule and two smaller guttules. Paraphyses multiseptate, branched, with expanded apex, containing a red-orange to slightly rosy pigment that turns greenish in Meltzer's. Paramarginal hairs yellowish-brown, fusiform, 75–150 µm, tightly crowded, fasciculate, multiseptate, with acute or obtuse apex, some well differentiated, others only poorly, with thickened walls ≤3 µm.

Fig 1. *Hymenoscyphus kathiae* (VANF A.K. 1877)
a. Ascomata; b. Ascospores; c. Tips of asci and paraphyses; d. Ascus;
e. Paraphyses; f. Ascus base.

Fig 2. *Parascutellinia violacea* (VANF A.K. 2961)
a. Ascomata; b. Ascospores; c. Paraphyses; d. Hairs; e. Asci

Specimen examined—**TURKEY, Van, Gürpınar,** Güzelsu village, river side, under *Salix* sp., 38°18'59"N–43°48'00"E, 1977 m, 05.10.2016, A.K. 2961 (VANF).

Comments— *Parascutellinia violacea* resembles *P. carneosanguinea,* which differs by carotenoid pigments within its paraphyses (Svrček 1975). Although

Van Vooren (2007) reported the same maximum sizes for the ascomata (5 mm) and asci as for *P. violacea,* some fruit bodies in our Turkish material measured almost 6 mm with asci up to 320 µm. Our specimens represent the first record of both genus and species for Turkey.

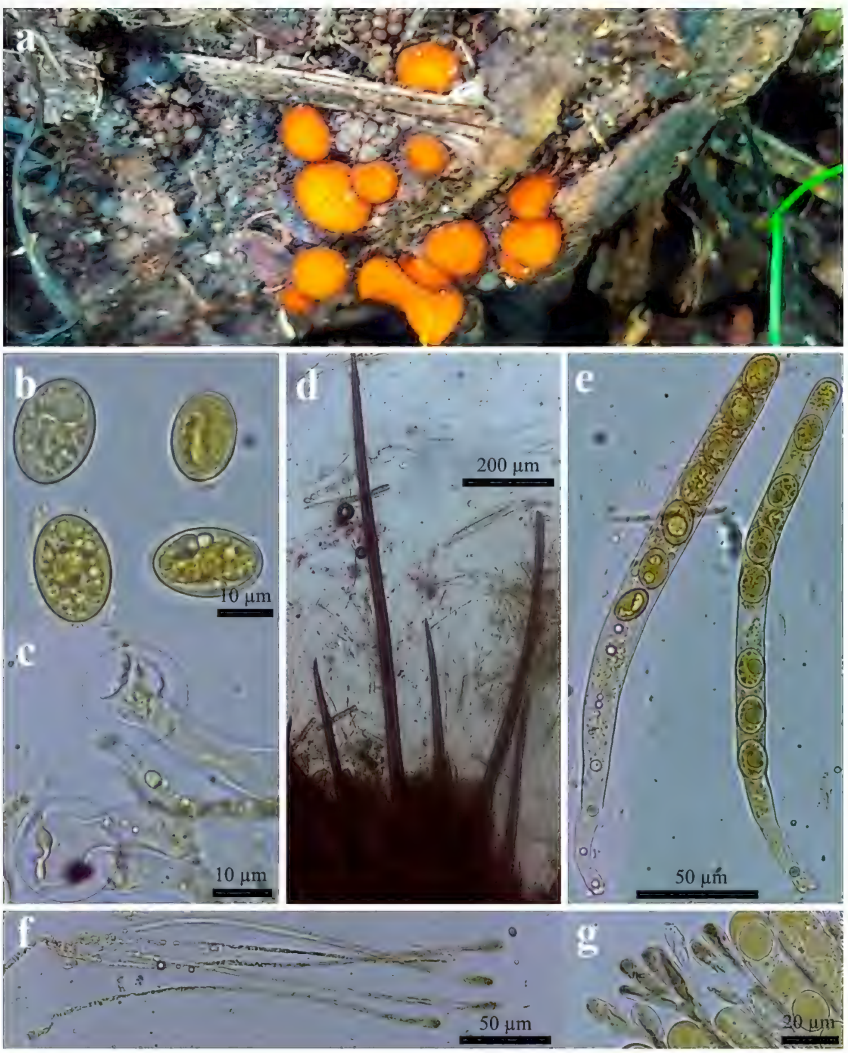

Fig 3. *Scutellinia crinita* (VANF A.K. 2963)
a. Ascomata; b. Ascospores; c. Ascal bases; d. Hairs; e. Asci;
f. Paraphyses; g. Apices of paraphyses.

Scutellinia crinita (Bull.) Lambotte,
Mém. Soc. roy. Sci. Liège, Sér. 2, 14: 301 (1887) Fig. 3

Apothecia 3–7(–9) mm diam., disc-shaped, without stalk. Hymenium light orange, edges and outer surface covered with long dark brown hairs. Hairs 880–1550 × 22–40 µm, thick-walled, multiseptate, dark brownish, surface mostly smooth, sometimes cracked. Asci 207–250 × 12–22 µm, and cylindrical. Ascospores 16–22 × 15–18 µm, broadly rounded ellipsoid, slightly verrucose, containing many small droplets. Paraphyses filiform, clavate at apex, septate, somewhat branched.

Specimens examined—**TURKEY, Van, Gevaş,** at the vicinity of Kuzgunkiran tunnel, on rotten and damp wood under *Populus* sp., 38°22'09"N–42°47'40" E, 2052 m, 13.06.2018, A.K. 2963 (VANF).

Comments— The maximum size of ascomata for *Scutellinia crinita* was reported as 10 mm by Matočec & Antonić (1995) and 18 mm by Thompson (2013), but none of our ascomata measured >9 mm. This species represents a new record for Turkey.

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Lemonniera yulongensis sp. nov. from Yunnan, China

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Abstract—*Lemonniera yulongensis,* isolated from submerged decaying leaves on Yulong Snow Mountain, is described as a new species. The fungus is characterized by monophialidic conidiogenous cells and branched conidia with mainly four septate arms. The new species also extends the distribution of *Lemonniera* into higher elevations than is typical for the genus.

Key words—aquatic hyphomycetes, fungal diversity, *Helotiales*, taxonomy

Introduction

Lemonniera De Wild. was proposed with *L. aquatica* De Wild. as type species (De Wildeman 1894). The genus is characterized by typically tetraradiate conidia with branches arising more or less simultaneously from a globose primordium and phialidic conidiogenous cells growing at the tip of branched or unbranched conidiophores. Seven species are currently accepted in the genus; Descals & al. (1977) reviewed the morphology and ecology and provided a key to six species, and Sinclair & Morgan-Jones (1979) described a new species isolated from an Alabama stream. Although some *Lemonniera* strains have been collected in terrestrial habitats, most have been isolated from streams, rivers, or ponds (Descals & al. 1977, Sinclair & Morgan-Jones 1979). The cosmopolitan genus has been recorded from Africa, Asia, Europe,

# Yu & Lv contributed equally to this research.

North America, and Australasia (De Wildeman 1894; Ingold 1942, 1958, 1968; Ranzoni 1953; Tubaki 1958; Petersen 1963; Descals & al. 1977; Sinclair & Morgan-Jones 1979; Seifert & al. 2011).

During a study of aquatic hyphomycetes in Yunnan Province, China, we encountered an unknown fungus that corresponded with the features of *Lemonniera*. We describe it here as a new species, *L. yulongensis*.

Materials & methods

The culture was isolated from decaying leaves submerged in a river on Yulong Snow Mountain, Lijiang county, Yunnan province, in April 2015. The leaves were cut into 2–4 × 2–4 cm fragments and then stretched out on the surface of CMA (20 g cornmeal, 18 g agar, 40 mg streptomycin, 30 mg ampicillin, 1000 ml distilled water) for ten days. Single conidia were captured using a sterilized toothpick while viewing with a CX31 microscope and cultivated on CMA in Petri plates. The cultures were examined after a one-week incubation at 28°C and morphological characters noted. Pure cultures and a permanent slide have been deposited in the Herbarium of the Laboratory for Conservation and Utilization of Bio-resources, Yunnan University, Kunming, P.R. China (YMF; formerly Key Laboratory of Industrial Microbiology and Fermentation Technology of Yunnan).

Taxonomy

Lemonniera yulongensis Z.F. Yu, **sp. nov.** PLATE 1

MYCOBANK MB 827810

Differs from *Lemonniera alabamensis* by its wider, 1(–2)-septate conidial arms.

TYPE: China, Yunnan Province, Lijiang county, Yulong Snow Mountain, 27°06′32″N 100°15′12″E, alt. 3033 m, in a river on submerged leaves of an unidentified dicotyledonous plant, 4 Apr. 2015, Ze-Fen Yu. (**Holotype**, YMF 1.044181 [metabolically inactive permanent slide]); ex-type culture, YMF1.04418).

ETYMOLOGY: Latin, *yulongensis,* referring to the site from which the species was isolated.

COLONIES 20 mm diam. on CMA after 20 days at 25°C. Mycelium hyaline, partly superficial and partly immersed, composed of branched, septate, hyaline hyphae. CONIDIOPHORES macronematous, mononematous, sometimes unbranched or bifurcate or penicillate branched towards the apex, septate, 50–200 × 3–4 µm, straight or flexuous, CONIDIOGENOUS CELLS monophialidic, terminal, integrated or discrete, hyaline, 17.5–27.5 × 6–6.5 µm. CONIDIA hyaline, radial, with a very distinct spherical or globose central cell of 4–6 µm diam, connected by 4 (rarely 3 or 5) arms radially extending from the globose central cell, branches more or less equilateral, subulate, apex rounded, 1(–2)-septate, (17.5–)22–42 × 4.8–6.1(–8.0) µm.

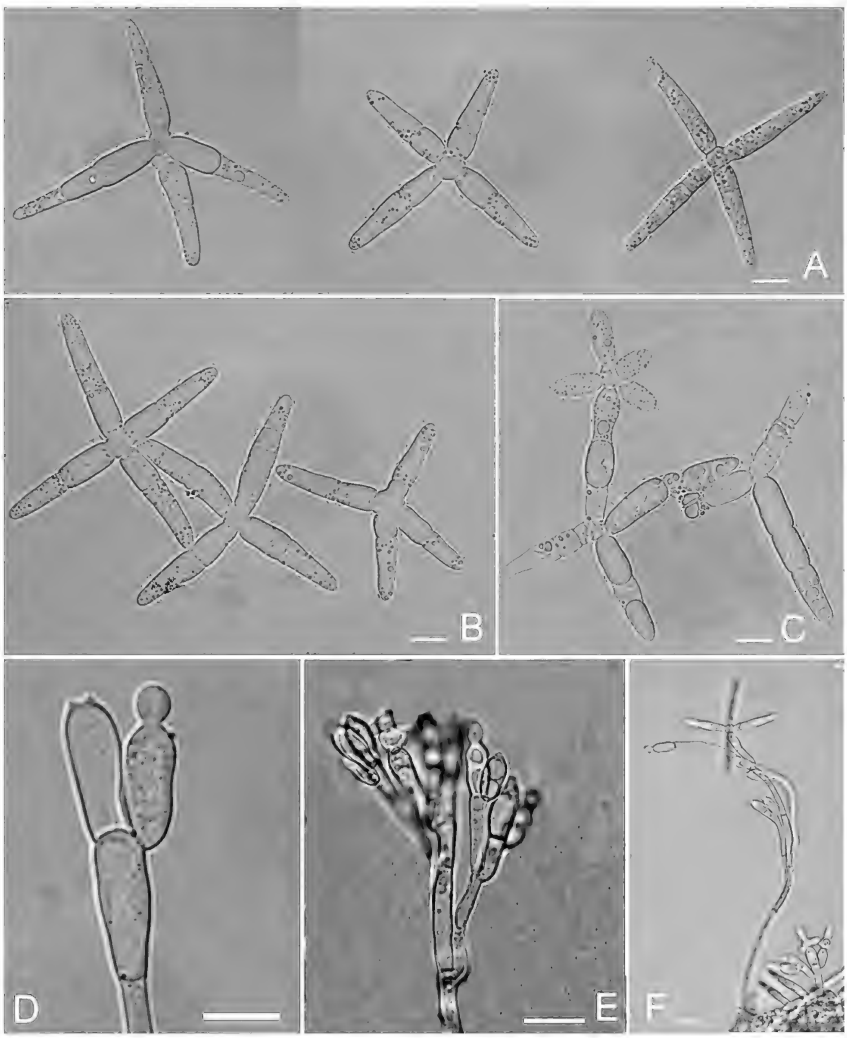

Plate 1. *Lemonniera yulongensis* (holotype, YMF 1.04418): A, B. Conidia; C. Conidia growing from old conidia. D, E. Conidiogenous cells. F. Conidiophores and conidia. Scale bars: A–E = 10 μm; F = 20 μm.

Discussion

Lemonniera yulongensis fits well within the genus *Lemonniera* based on its typically tetraradiate conidia with branches arising from the central body and phialidic conidiogenous cell growing at the tip of main apex or branches of conidiophores.

Lemonniera species have been divided into two groups based on the presence or absence of a central body in the conidia. *Lemonniera alabamensis* R.C. Sinclair & Morgan-Jones, *L. centrosphaera* Marvanová, *L. pseudofloscula* Dyko, and *L. yulongensis* all possess central bodies in their conidia. However, the central conidial body is not as distinct in *L. yulongensis* as those of the other three species. The conidial arms in *L. centrosphaera* and *L. pseudofloscula* are longer than in *L. yulongensis; L. alabamensis,* which produces similarly shaped conidia, is distinguished from *L. yulongensis* by its 2-septate, narrower (2–3 µm diam.) arms (Sinclair & Morgan-Jones 1979).

Five *Lemonniera* species have been reported previously from China: *L. alabamensis* from Beijing (Liu & al. 1992), *L. centrosphaera* from Anhui and *L. cornuta* Ranzoni from Beijing (Yu 1988), *L. filiformis* R.H. Petersen ex Dyko from Anhui (Yu 1988) and Taiwan (Chao 2006), and *L. aquatica* and *L. terrestris* Tubaki from Sichuan (Zhu & Yu 1992). The localities of all five occur at low (970–1100 m) elevations, so the discovery of *L. yulongensis* at higher altitudes area widens the known distribution of the genus.

Acknowledgements

This work was jointly financed by National Natural Science Foundation Program of PR China (31570023, 31770026). We are grateful to Prof. X.G. Zhang and Dr. R.F. Castañeda-Ruiz for critically reviewing the manuscript and providing helpful suggestions to improve this paper, and to Dr. Shaun Pennycook and Dr. Lorelei Norvell for their critical review and suggestions.

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Contributions to species of *Xylariales* in China—2. *Rosellinia pervariabilis* and *R. tetrastigmae* spp. nov., and a new record of *R. caudata*

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Abstract—Three species of *Rosellinia* collected from China are reported based on morphological and molecular characteristics. *Rosellinia pervariabilis* is proposed as a new species, differentiated by its narrow ascospores (19.5–24.5 × 4–5 μm) without a germ slit. *Rosellinia tetrastigmae* is also proposed as new and differentiated by its small stromata. *Rosellinia caudata* is reported as a new record from the Chinese mainland. Detailed morphological descriptions and illustrations are provided, and many new DNA sequences are cited.

Key words—*Ascomycota*, pyrenomycetous fungi, *Xylariaceae*, taxonomy

Introduction

This is the second in a planned series of papers on *Xylariales* from China (Long & al. 2019). *Rosellinia,* introduced by De Notaris (1844), a large genus

in terms of species number in the *Xylariaceae* Tul. & C. Tul. (Wijayawardene & al. 2017). Despite the recent resurrection of *Hypoxylaceae* DC, *Rosellinia* remains assigned to *Xylariaceae* (Wendt & al. 2018, Daranagama & al. 2018, Wijayawardene & al. 2018). *Rosellinia* is a species rich genus, especially in tropical and subtropical areas (Petrini 1992, 2003, 2013a). In 2013, 142 *Rosellinia* species were accepted based on the morphological studies of numerous specimens (including many type specimens) from different parts of the world (Petrini 2013a). Currently, 41 species of *Rosellinia* have been reported from China (Teng 1963, Tai 1979, Ju & Rogers 1990, 1999; Yuan & Zhao 1993, Lu & al. 2000, Liu & al. 2010, Petrini 2013a, b; Li & Guo 2015, 2016, 2018; Li & al. 2015, Su & al. 2016). The taxonomic concept of *Rosellinia* and the terminology applied in this paper follow Petrini (2013a).

During our investigation of *Xylariales* in China, two new species and one new record of *Rosellinia* were found from Guizhou province. In addition, newly obtained DNA sequence data are reported in this paper.

Materials & methods

Collection & isolation

Fresh materials collected in southwestern China were brought to the laboratory in paper bags. Macroscopic characters were examined under an Olympus SZ61 stereomicroscope and photographed with a fitted Canon 700D digital camera (Senanayake & al. 2015). Materials were mounted in water and Melzer's reagent for anatomical examination; asci, ascospores, and ascus apical rings were photographed using a Nikon digital camera fitted to a light microscope. More than 30 ascospores, 20 asci, and 20 apical rings were measured for each specimen. Pure colonies were obtained by single-spore isolation following Chomnunti & al. (2014), and successful cultures were preserved in 2 ml screw cap centrifuge tubes with 10% glycerol at –20 °C and with sterile water at 4 °C. Herbarium materials were deposited at the herbarium of Guizhou Medical University, Guizhou, China (GMB) and the Herbarium of Cryptogams, Kunming Institute of Botany, Academia Sinica, Yunnan, China (KUN-HKAS). Cultures were deposited at Guizhou Medical University Culture Collection (GMBC).

DNA extraction, PCR amplification, sequencing

Colonies were transferred to 2% potato-dextrose agar (PDA) medium and incubated at 25 °C until the hyphae filled the plate. Fresh mycelia were scraped off the medium with a clean scalpel blade. Total genomic DNA was extracted from fresh mycelia using a Biomiga GD2416 Fungus Genomic DNA Extraction Kit (Su & al. 2016). DNA products were preserved at –20 °C.

ITS rDNA regions were amplified with primer pairs ITS4 and ITS5; α-actin gene (ACT) sequence fragments were amplified with primer pairs ACT512F and ACT783R

Table 1. Taxa of *Rosellinia* and related genera used in the molecular analyses.

Taxon	Culture number	GenBank acc. no.		Reference
		α-actin	β-tubulin	
Amphilogia gyrosa	YMJ 91123101	EF025600	EF025615	Hsieh & al. 2010
Annulohypoxylon nitens	YMJ 91022108	AY951772	AY951663	Hsieh & al. 2005
A. squamulosum	YMJ 90081905	AY951774	AY951665	Hsieh & al. 2005
Astrocystis bambusae	89021904 (HAST)	GQ449239	GQ495942	Hsieh & al. 2010
A. mirabilis	94070803 (HAST)	GQ449238	GQ495941	Hsieh & al. 2010
A. sublimbata	89032207 (HAST)	GQ449236	GQ495940	Hsieh & al. 2010
Biscogniauxia anceps	YMJ 123 [**T**]	AY951783	AY951671	Hsieh & al. 2005
B. arima	YMJ 122	AY951784	AY951672	Hsieh & al. 2005
B. capnodes	YMJ 138	AY951787	AY951675	Hsieh & al. 2005
B. mediterranea	YMJ 147	AY951796	AY951684	Hsieh & al. 2005
B. simplicior	YMJ 136	AY951798	AY951686	Hsieh & al. 2005
Collodiscula leigongshanensis	GZUH0107 [**T**]	—	KR002587	Li & al. 2015
C. fangjingshanensis	GZUH0109 [**T**]	—	KR002589	Li & al. 2015
Daldinia caldariorum	YMJ 263	AY951802	AY951690	Hsieh & al. 2005
D. childiae	CBS 122881	KU684039	KU684129	U'Ren & al. 2016
Durotheca comedens	BCC25152	GQ160480	GQ160488	Læssøe & al. 2013
D. depressa	BCC28073	GQ160484	GQ160492	Læssøe & al. 2013
Hypoxylon rubiginosum	YMJ 24	AY951862	AY951751	Hsieh & al. 2005
H. shearii var. *minor*	YMJ 29	AY951864	AY951753	Hsieh & al. 2005
Jackrogersella cohaerens	YMJ 310	AY951766	AY951655	Hsieh & al. 2005
Kretzschmaria clavus	YMJ 114	EF025596	EF025611	Hsieh & al. 2010
K. guyanensis	89062903 (HAST)	GQ408901	GQ478214	Hsieh & al. 2010
K. lucidula	YMJ 112	EF025595	EF025610	Hsieh & al. 2010
K. megalospora	YMJ 229	EF025594	EF025609	Hsieh & al. 2010
Nemania abortiva	467 (BISH) [**T**]	GQ374123	GQ470219	Hsieh & al. 2010
N. illita	YMJ 236 [**T**]	EF025593	EF025608	Hsieh & al. 2010
N. primolutea	YMJ 91102001[**T**]	EF025592	EF025607	Hsieh & al. 2010
N. serpens	235 (HAST)	GQ389695	GQ470223	Hsieh & al. 2010
Podosordaria muli	167 (WSP) [**T**]	GQ455450	GQ844839	Hsieh & al. 2010
Poronia pileiformis	88113001 (WSP)[**T**]	GQ455449	GQ502720	Hsieh & al. 2010
Rosellinia aquila	MUCL 51703	—	KX271253	Wendt & al.2018
R. buxi	99 (JDR)	GQ398228	GQ470228	Hsieh & al. 2010
R. caudata	**GMBC0145**	**MH771031**	**MH778499**	**This study**
	GMBC0207	**MH771029**	**MH778497**	**This study**
	GMBC0208	**MH771030**	**MH778498**	**This study**
R. convexa	GZUCC13005 [**T**]	KF885726	KF885725	Su & al. 2016
R. corticium	MUCL 51693	—	KX271254	Wendt & al. 2018
R. lamprostoma	YMJ 89112602	EF025589	EF025604	Hsieh & al. 2010

R. necatrix	YMJ 89062904	EF025588	EF025603	Hsieh & al. 2010
R. pervariabilis	**GMBC0092 [T]**	**MH771027**	**MH778495**	**This study**
R. sancta-cruciana	90072903 (HAST)	GQ389699	GQ470227	Hsieh & al. 2010
R. tetrastigmae	**GMBC0030 [T]**	**MH771028**	**MH778496**	**This study**
Stilbohypoxylon elaeidicola	YMJ 173	EF025601	EF025616	Hsieh & al. 2010
S. quisquiliarum	YMJ 89091608	EF025591	EF025606	Hsieh & al. 2010
Theissenia pyrenocrata	TC11480	GQ247716	GQ247717	Læssøe & al. 2013
Whalleya microplaca	YMJ 91111215	EF025599	EF025614	Hsieh & al. 2010
Xylaria acuminatilongissima	623 (HAST) **[T]**	GQ853046	GQ502711	Hsieh & al. 2010
X. brunneovinosa	720 (HAST) **[T]**	GQ853041	GQ502706	Hsieh & al. 2010

Note: New sequences in **bold**; ex-type sequences designated by '**[T]**'

(Carbone & Kohn 1999); the β-tubulin gene (BT) was amplified using primer pairs T11 and T1 (Tanaka & al. 2009; Hsieh & al. 2010). Amplification conditions followed Li & al. (2015) and Su & al. (2016). After DNA was amplified using the polymerase chain reaction (PCR), the PCR products were sent to Sino Geno Max in Beijing for DNA sequencing. All nucleotide sequences obtained were uploaded into GenBank, and the accession numbers of DNA sequences used in this paper are listed in Table 1.

Sequence alignment and phylogenetic analyses

Preliminary BLAST searches of ITS rDNA sequences placed our sequences close to those of *Rosellinia* spp. Sequences used for constructing phylogenetic tree in this paper were chosen according to the latest authoritatively published papers and the results of preliminary BLAST searches (Su & al. 2016, Wendt & al. 2018, Daranagama & al. 2018).

Sequences were downloaded and aligned using BioEdit (Hall 1999). The combined dataset was concatenated from individual ACT and BT alignments, with alignments checked and improved manually where appropriate and uploaded in TreeBASE (https://treebase.org/treebase-web/home.html). We used an online tool (http://sing.ei.uvigo.es/ALTER/) to convert files for RAxML and MrBayes (Ronquist & al. 2012). The NEXUS file was modified with MrModeltest v. 2.2 (Nylander 2004).

Randomized accelerated maximum likelihood (RAxML) was conducted using RAxML online (https://www.phylo.org/portal2/). Parameters for RAxML followed Phookamsak & al. (2015). Bayesian analysis was performed with MrBayes v.3.1.2 (Ronquist & al. 2012) via a uniform [GTR+I+G] model (lset nst = 6, rates = invgamma, Prsetstatefreqpr = dirichlet, 1, 1, 1, 1) inferred by MrModeltest 2.3. The phylograms were visualized in Figtree 1.4.3 and polished in Adobe Photoshop version CS6 (Fig. 1).

Results

Three species of *Rosellinia*, two new species and a new record for the Chinese mainland, were recorded.

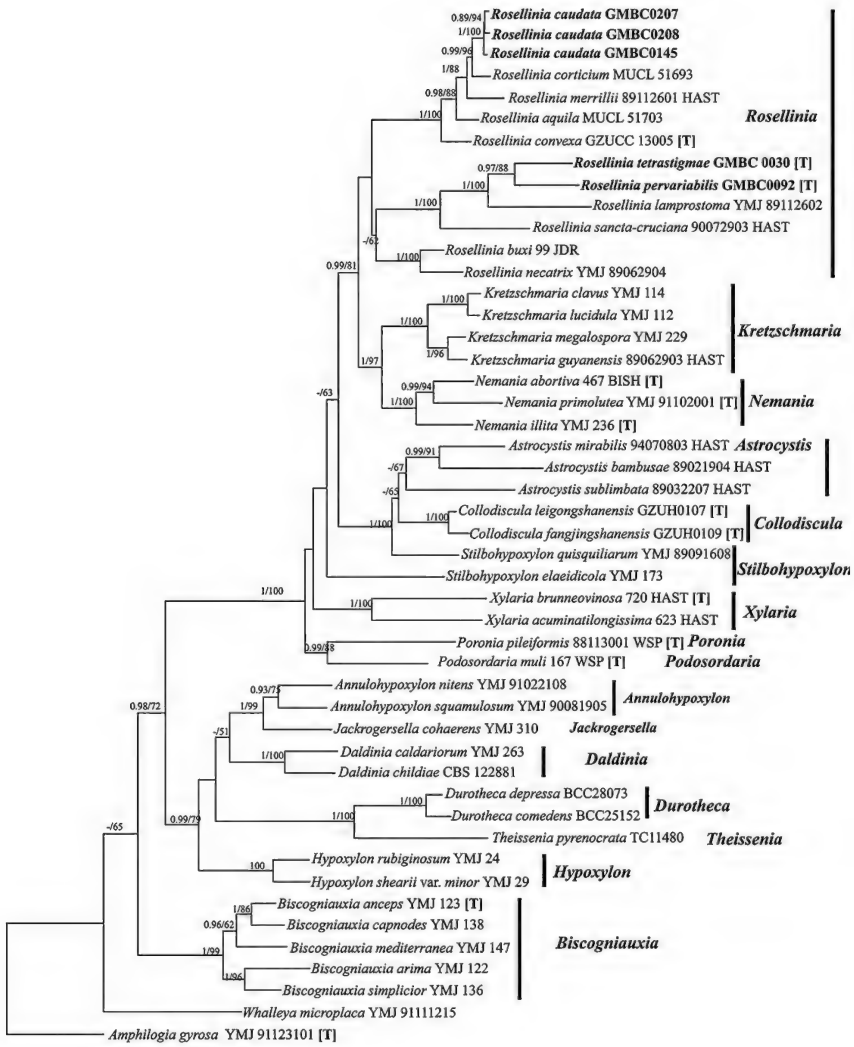

Fig. 1. RAxML tree for *Rosellinia* and related genera based on a combined dataset of β-tubulin and α-actin gene segment sequences. Bayesian posterior probabilities >0.95 and bootstrap support values for maximum likelihood (ML) higher than >50% are marked above the nodes; an en-dash ("–") indicates a value <0.95 (PP) or <50% (BS). Strain numbers are noted after the species names. Our new sequences are shown in bold; and ex-type sequences are annotated with '[T]'. The tree is rooted via the outgroup *Amphilogia gyrosa* YMJ 91123101.

Phylogenetic analyses

Phylogenetic trees were generated with the RAxML and MrBayes methods by using combined datasets of BT and ACT sequences. Forty-seven fungal strains representing 15 different genera were analysed. After manual adjustment, the alignments consisted of 1130 character positions in the BT alignment and 334 in the ACT alignment, of which 92 characters were variable, 715 constant, and 657 parsimony informative. Two different molecular markers were used, and two tree reconstruction methods were applied.

The result of the phylogenetic analysis is shown in Fig. 1 with the final ML optimization likelihood value of –21722.880899. Our isolates fell within genus *Rosellinia*. Our strains formed separate branches on the phylogenetic tree obtained via most parsimonious analysis of the ITS rRNA gene dataset (supplementary material). *Rosellinia tetrastigmae* and *R. pervariabilis* showed a close relationship with *R. lamprostoma* Syd. & P. Syd., with *R. pervariabilis* and *R. tetrastigmae* supported as independent species. Our *R. caudata* three specimens clustered together with *R. corticium* with high bootstrap values (0.99/96).

Taxonomy

Rosellinia pervariabilis Q.R. Li & J.C. Kang, **sp. nov.** Fig. 2

MycoBank MB 827512

Differs from *Rosellinia culmicola* by its smaller ascospores and the absence of a germ slit.

Type—China, Guizhou Province: Qiannan Buyei & Miao Autonomous Prefecture, Maolan National Nature Reserve, on the stem of *Bambusa pervariabilis* McClure, VII 2016, Li 16029 (**Holotype**, GMB 0092; **isotype**, HKAS 101452; ex-type living culture, GMBC 0092).

Etymology—In reference to the host, *Bambusa pervariabilis*.

Saprobic on stem of *B. pervariabilis*. Sexual morph—Subiculum composed of finely interwoven hypha, brown to reddish brown, persistent. Stromata scattered to gregarious, solitary, superficial, subglobose to conical, dark, 0.3–0.5 mm diam., 0.4–0.8 mm high, each containing a single perithecium. Ostioles finely papillate. Ectostroma 20–40 μm thick, black, carbonaceous. Entostroma confined to base, black. Perithecia globose to subglobose. Paraphyses hyaline, septate. Asci 90.5–138 × 9.5–15 μm, 8-spored, cylindrical, unitunicate, short-pedicellate, with a J+ (staining blue in iodine), long barrel-shaped apical ring, 7.5–9 μm high, 3–4.5 μm diam. Ascospores 19.5–24.5 × 4–5 μm, overlapping uniseriate, botuliform, ends

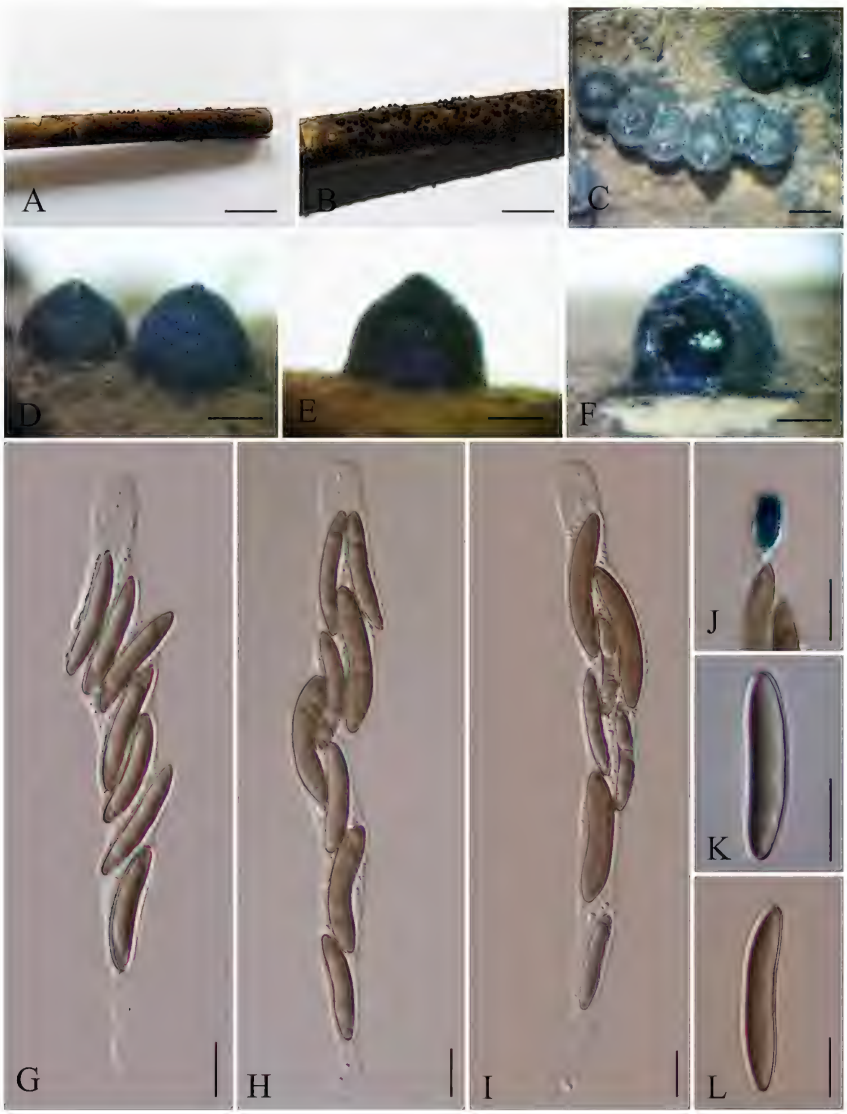

Fig. 2. *Rosellinia pervariabilis* (holotype, GMB 0092). A–E. Stromata on the host. F. Section of stroma. G–I. Asci. J. Long barrel-shaped J+ apical ring. K, L. Ascospores. Scale bars: A, B = 0.2 cm; C, D = 500 μm; E, F = 200 μm; G–L = 10 μm.

rounded, brown to yellowish brown, unicellular, smooth, lacking sheath and germ slit. Asexual morph: unknown.

Comments: *Rosellinia pervariabilis* is diagnosed by its uniquely shaped ascospores and lack of a germ slit. Although there are many *Rosellinia* species producing ascospores within the 15–25 µm range (e.g., *R. abscondita* Rehm, *R. helvetica* L.E. Petrini & al., *R. hyalospora* Theiss), their ascospores have a much lower (≤4) length : width ratio (Petrini 1992, 2003, 2013a). *Rosellinia culmicola* has larger ascospores (24.2±1.5 × 5.9±0.6 µm) and a 6–7 µm long germ slit; moreover, it has a stromatal ring (Petrini 2013a).

Rosellinia tetrastigmae Q.R. Li & J.C. Kang, **sp. nov.** Fig. 3

MycoBank MB 828157

Differs from *Rosellinia megalosperma* by its smaller stromata; and from *R. procera* by its smaller stromata and its ascospores having a germ slit.

Type—China, Guizhou Province: Qiannan Buyei & Miao Autonomous Prefecture, Maolan National Nature Reserve, on the stem of *Tetrastigma sp.* (*Vitaceae*), VII 2016, Li 16012 (**Holotype**, GMB 0030; **isotype**, HKAS 101457; ex-type living culture, GMBC 0030).

Etymology—In reference to the host genus, *Tetrastigma*.

Saprobic on the twigs of dicot wood. Sexual morph—Subiculum composed of finely interwoven hypha, black, persistent. Stromata scattered or gregarious, solitary, superficial, cupulate to oblate sphere, 0.4–0.6 mm diam., 0.3–0.5 mm high, each containing a single perithecium, embedded in the subiculum slightly. Ostioles finely papillate or integrated. Ectostroma 25–50 µm thick, black, carbonaceous. Entostroma black, confined to stroma base. Perithecia subglobose, not collapsed. Paraphyses hyaline, septate. Asci 185–240 × 32–45 µm, 8-spored, cylindrical, overlapping biseriate, unitunicate, short-pedicellate, with a J+, barrel-shaped apical ring, 16–22.5 µm high, 8.5–11.5 µm diam. Ascospores 72.5–111.5 × 12.5–19.5 µm, asymmetrically ellipsoidal with broadly round ends, yellowish brown to dark brown, smooth, surrounded at each end by slimy caps, with a straight germ slit extending the length of the spore on the flat side. Asexual morph: unknown.

Additional material examined—**CHINA, Guizhou Province, Qiannan Buyei & Miao Autonomous Prefecture,** Maolan National Nature Reserve, on the twigs of unknown plant, VIII 2017, Li 17103 (GMB 0212).

Comments: *Rosellinia tetrastigmae* resembles *R. procera* Syd. & P. Syd. and *R. megalosperma* Syd. & P. Syd. San Martín & Roger (1995). Although Ju & Roger (1999) regarded *R. procera* and *R. megalosperma* as synonyms, Petrini (2013a) treated them as independent species based on the presence of ascospore germ slits in *R. megalosperma* and their absence in *R. procera*. *Rosellinia*

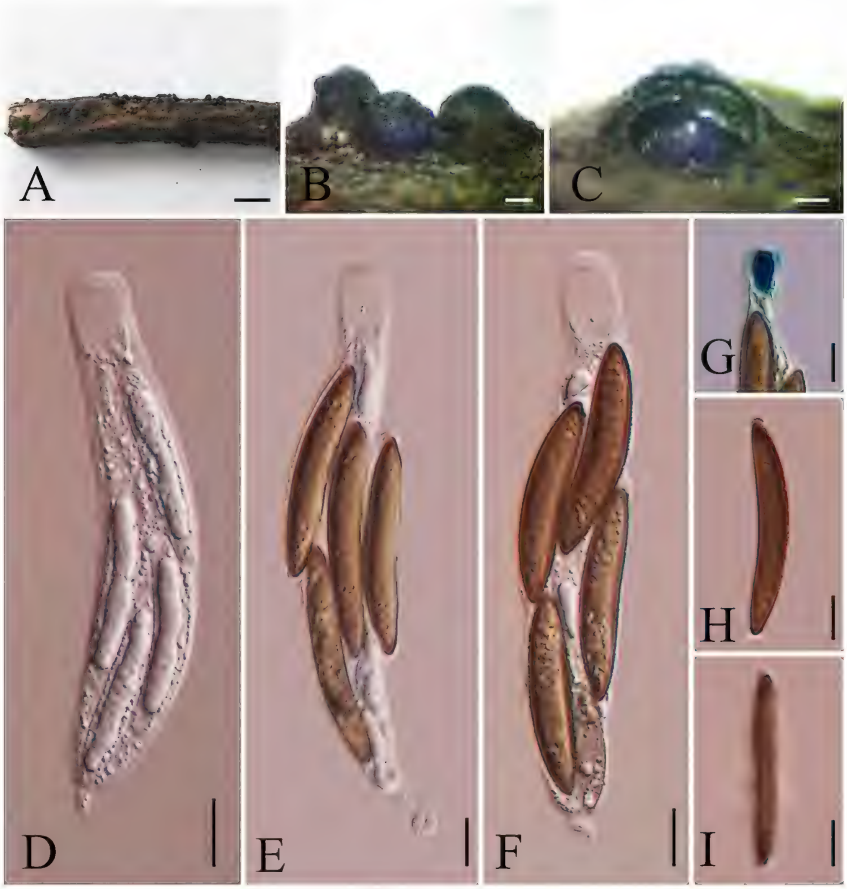

Fig. 3. *Rosellinia tetrastigmae* (holotype, GMB 0030). A, B. Stromata on the host. C. Section of stroma. D–F. Asci. G. Barrel-shaped J+ apical ring. H, I. Ascospores. Scale bars: A = 0.5 cm; B = 200 µm; C= 100 µm; D–I = 20 µm.

tetrastigmae differs from both by its smaller stromata (*R. megalosperma* —600–1000 µm high, 750–1100 µm wide; *R. procera*—825–975 µm high, 550–875 µm wide; Petrini 2013a).

Rosellinia caudata Petch, Ann. Roy. Bot. Gard. (Peradeniya) 10: 135 (1926) Fig. 4

Saprobic on the twigs of dicot wood, forming on the host surface. Sexual morph—Subiculum composed of finely interwoven hypha, well developed, brown to red brown, persistent. Stromata scattered or densely gregarious,

superficial, subglobose to cupulate, dark brown, 0.8–1.2 mm diam., 0.7–1 mm high, containing single perithecia. Ostioles finely papillate. Ectostroma 50–110 µm thick, black, carbonaceous. Entostroma confined to base, black. Perithecia subglobose to cupulate. Paraphyses hyaline, septate. Asci 165–245 × 7.5–15.5 µm, 8-spored, cylindrical, unitunicate, short-pedicellate, with a J+ (staining blue in iodine), long barrel-shaped apical ring, 6–13.5 µm high, 5.5–7.5 µm diam. Ascospores 21.5–30.5 × 7–11 µm, slightly overlapping uniseriate, asymmetrically ellipsoidal with broadly rounded ends, cellular appendage at one end in mature ascospores, brown to dark brown, unicellular, smooth, with a slimy sheath, on convex side with straight germ slit as long as spore. Asexual morph: unknown.

Material examined—**CHINA, Guizhou Province, Qiannan Buyei & Miao Autonomous Prefecture**, Maolan National Nature Reserve, on twigs of unknown plant, VII 2016, Li 16102 (GMB 0145; living culture, GMBC 0145); **Guiyang,** Guizhou Medical University Campus, on twigs of dicotyledonous wood, IV 2017, Li 17115 (GMB 0207; living culture, GMBC 0207); Huaxi Yingbinguan Hotel Park, on twigs of dicotyledonous wood, VII 2017, Li 17126 (GMB 0208; living culture, GMBC 0208).

Comments: Our strains were identified as *Rosellinia caudata,* which are morphologically similar to *R. corticium* (Schwein.) Sacc., *R. aquila* (Fr.) Ces. & De Not., and *R. merrilli* Syd. & P. Syd. (Petrini 2013a). *Rosellinia caudata* also shows a close affiliation with *R. corticium*, *R. merrilli*, and *R. aquila* in the phylogenetic tree (Fig. 1); however, *R. corticium* differs by its larger stromata, *R. aquila* differs by its smaller ascospores and larger stromata, and *R. merrilli* differs by its larger ascospores with a cellular appendage at each end (Petrini 2013a). Petrini (2013a) reported a specimen of *R. caudata* from Taiwan, but we believe that our specimens represent a new record for the Chinese mainland. We also report the first BT and ACT sequences for *R. caudata*.

Discussion

Morphological characteristics are widely used to distinguish between similar species of *Rosellinia*. Stroma shape, presence of subiculum, texture and color, apical ring, ascospore shape and dimensions are important diagnostic characters for *Rosellinia* (Petrini 2005, 2013a). *Rosellinia* species with similarly sized ascospores clustered together clearly in the ITS-based phylogeny by Su & al. (2015). Our analyses show a similar trend (Fig. 1). However, out of more than 142 taxa very few sequences have been uploaded to GenBank, suggesting that *Rosellinia* is still not yet well studied phylogenetically. Much herbarium material is in poor condition and cannot

Fig. 4. *Rosellinia caudata* (GMB 0145). A–D. Stromata on the host. E. Section of stroma. F, G Barrel-shaped J+ apical ring. H–K. Asci. L–O. Ascospores. Scale bars: A = 0.5 cm; B–E = 200 μm; F–O = 10 μm.

be used for sequencing. This paper provides sequences from new *Rosellinia* collections, which should prove beneficial to systematic molecular taxonomy of the *Rosellinia*.

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Catalog of *Penicillium* spp. causing blue mold of bulbs, roots, and tubers

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Abstract—Accuracy in assigning specific epithets to *Penicillium* isolates documented as agents of blue mold of edible and ornamental bulb, root, and tuber crops is highly variable—with methods ranging from appropriate (recent morpho-cultural criteria, metabolite production, DNA sequences), to plausible (older morpho-cultural criteria from monographs), to suspect (unspecified methods, identification via inappropriate literature). We provide a catalogue appropriate for plausibly assigned names accompanied by authorities, references, host distribution, and identification methodology. Names are categorized according to (i) segregates of *P. corymbiferum* (i.e., names in *P.* subg. *Penicillium*) and taxa in *P.* ser. *Corymbifera* associated with *Liliaceae* s.l.; (ii) taxa in *P.* subg. *Penicillium* other than *P.* ser. *Corymbifera* associated with *Liliaceae* s.l.; (iii) taxa other than *P.* subg. *Penicillium* associated with *Liliaceae* s.l.; (iv) associates of *Beta vulgaris* (beets and sugar beets); and (v) associates of mostly tropical or subtropical roots and tubers. Ambiguities or deficiencies in assignment of certain specific epithets are noted.

Key words—*Allium, Dioscorea, Iris, Manihot, Zingiber*

Introduction

Previously attributed to a small number of *Penicillium* species, blue mold pathogens on bulb and root crops have been assigned by modern molecular-genetic methods to an increasing number of species, many of which represent "cryptic" species segregated from other species described decades ago (Dugan & Everhart 2016). In comparing sets of investigations, results from artificial inoculations reveal substantial areas where host ranges agree as well as

instances with contradictory results (Dugan & al. 2014, 2017; Overy & al. 2005). As new species are still being described and new host records published (e.g., Strausbaugh & Dugan 2017, Oh & al. 2015, Sang & al. 2014), there is a need for a catalog of names for *Penicillium* species causing blue mold diseases of bulb and root crops that also cites the literature on hosts and indicates how isolates were identified. Because numerous publications record *Penicillium* species on various bulb, root, or tuber hosts without clearly indicating how isolates were identified to species level, we emphasize literature with well-defined identification methods. Species names in *Penicillium* are provided with authors, dates, and publication references (Index Fungorum 2018) for species of greatest importance to this review (Tables 1–5). We divide our topic into three main sections: blue mold on bulbs of *Liliaceae* sensu lato (Tables 1–3), blue mold on beets and sugar beets (Table 4), and blue mold on roots and tubers, many of which are tropical or subtropical (Table 5). We also note pertinent subgeneric classifications for Tables 1–3.

Tables 1–5 concisely summarize methods used to assign specific epithets for each publication cited. In some instances pertinent isolates that may have been obtained at different times or simultaneously are those characterized molecularly and publicly available from culture collections. For instance, Frisvad & Samson (2004), who characterized isolates using morpho-cultural methods (including extrolites), published in the same issue as Samson & al. (2004), who characterized the same isolates emphasizing β-tubulin DNA sequences; we also include isolates used by Overy & al. (2005), also previously characterized and readily available. In other instances, plausibly correct names were assigned earlier based on older monographs (e.g., Pitt 1980; Ramirez 1982; Raper & Thom 1968, 1949) whose methods were current at the time but not yet molecular-genetic. We also note instances where species names have become established in pertinent literature but for which identification methods were not specified or are problematic. We accept subgeneric classifications by Frisvad & Samson (2004), Houbraken & Samson (2011), Pitt (1980), or Visagie & al. (2014). Authorities and publication references are provided at first mention in Tables 1–5. We do not provide full synonymies for *Penicillium* names (particularly where varieties have been elevated to species or where a fungus has been transferred to *Penicillium* from another genus), but we do reference specific instances of disagreement over synonymy.

For more complete lists of accepted species and synonyms, readers are encouraged to refer to Farr & Rossman (2018), Frisvad & Samson (2004), Pitt (1980, 2000), MycoBank (2018), Species Fungorum (2018), Visagie & al.

(2014), and other literature mentioned in tables and text. The primary purpose of this catalogue is to assess the degree of confidence one should place in assigning a specific epithet by documenting the method(s) by which the name was assigned.

Blue mold on bulbs of *Liliaceae* sensu lato

For decades, blue mold on edible or ornamental bulbs was attributed to *Penicillium corymbiferum* Westling, Ark. Bot. 11(1): 92 (1911), presently regarded as a synonym of *Penicillium hirsutum* (e.g., Frisvad & Samson 2004, Pitt 1980, Species Fungorum 2018). Frisvad & Samson (2004) treated these and the following species within *P.* subg. *Penicillium*, *P.* sect. *Viridicata* (= *P.* sect. *Fasciculata*; Houbraken & Samson 2011), *P.* ser. *Corymbifera*. *Penicillium* sect. *Corymbifera* is not strictly phylogenetic, but a traditional group of convenience based partially on host (edible or ornamental bulbs) (Frisvad & al. 2000, Frisvad & Samson 2004). Dugan & al. (2014) provided details on the typification of *Penicillium allii*, *P. corymbiferum*, and *P. hirsutum*, focusing on repercussions for identifying and naming the agents that rot garlic (*Allium sativum*) in the field and in storage.

Literature is here summarized for results of artificial inoculation of various edible bulbs (various cultivars or varieties of onion, *Allium cepa* L., and garlic, *A. sativum* L.) and ornamental bulbs (ornamental onions, *Allium aflatunense* B. Fedtsch. and *A. stipitatum* Regel; crocus, *Crocus sativus* L.; grass lily, *Ornithogalum umbellatum* L.; daffodil, *Narcissus* 'Ice Follies;' *Gladiolus* 'Black Walnut' and two unnamed cultivars; *Iris* ×*hollandica*; *Tulipa gesneriana* L. and *Tulipa* 'Purple Prince') (Dugan & al. 2011, 2014, 2017; Overy & al. 2005). Not all plant taxa were challenged by each set of investigators. Species and cultivars sometimes differed, as did inoculation and incubation details.

Blue mold on beets and sugar beets

The most frequently reported *Penicillium* species on *Beta vulgaris* L. subsp. *vulgaris* (table beets, cv. group 'Conditiva' and sugar beets, cv. group 'Altissima') is *P. vulpinum* (most often reported under its synonym, *P. claviforme* Bainier), which is readily identifiable by its conspicuous coremia (Bugbee 1975, Fugate & Campbell 2009). However, several other species have been conclusively identified, and others are indicated in literature using ambiguous or potentially obsolete identification methods. Blue mold of beet is not treated in Koike & al. (2007), Sherf & MacNab (1986), or Snowdon (1992), but *P. vulpinum* has commonly been listed among the most important storage rot pathogens along

with an *Athelia*-like sp., *Botrytis cinerea* Pers., and *Phoma betae* A.B. Frank (Bugbee 1993, Strausbaugh & al. 2015). *Penicillium vulpinum* is an antagonist of *B. cinerea* (Bugbee 1976). *Penicillium* spp. have also been acknowledged to complicate the re-isolation of the slow growing *Athelia*-like sp. from sugar beet roots (Strausbaugh & al. 2015).

Rot lesions on sugar beet roots infested by *Penicillium* spp. in storage are normally associated with wounds created by harvest operations or other fungi (Fugate & Campbell 2009, Strausbaugh & al. 2015). Other *Penicillium* spp. documented as pathogenic on sugar beet roots in storage include: *P. cellarum, P. cyclopium*, *P. expansum*, *P. funiculosum*, and *P. polonicum* (Bugbee 1975, Bugbee & Nielsen 1978, Fugate & Campbell 2009, Strausbaugh 2018). A direct comparison of *P. cellarum*, *P. expansum*, and *P. polonicum* established that *P. expansum* and *P. polonicum* are the most virulent on sugar beet roots in long-term storage in Idaho (Strausbaugh 2018). In historical literature on sugar beet storage rots from the United States, *P. vulpinum* has been described as being the most prevalent *Penicillium* sp. in most environments (Bugbee 1993, Fugate & Campbell 2009). Sheikholeslami & al. (1998) also reported *P. vulpinum* on stored sugar beet roots in Iran. However, recent reports describe *P. expansum* as being the most prevalent species in sugar beet storages in the Czech Republic (Huijbregts 2013, Zahradníček 1996) and Japan (Uchino 2001), although the identification methods have not been detailed. In Idaho, both *P. expansum* and *P. cellarum* have recently been established as the most prevalent *Penicillium* spp. in long-term sugar beet piles (Strausbaugh 2018). Bugbee (1975) described *P. variabile* on stored roots in the Red River Valley (North Dakota), a fungus now regarded as a synonym of *P. expansum* in Farr & Rossman (2018), Frisvad & Samson (2004), and MycoBank (2018). *Penicillium variabile* is not included in the list of species accepted by Visagie & al. (2014) but is listed as an independent species by Species Fungorum (2018). Bugbee (1975) determined that *P. variabile* was not as virulent or as prevalent as *P. vulpinum* on sugar beet roots. *Penicillium* has also been cited from storages in Belgium, the Netherlands, and Sweden, but the species was not determined (Huijbregts & al. 2013). Some species described as pathogenic on sugar beet in storage—such as *P. cyclopium*, *P. funiculosum*, and *P. polonicum*—appear to be of minor importance.

Blue mold on edible roots and tubers

These crops, with the exception of horseradish, are primarily tropical to subtropical. Given that current criteria for assignment of species names have incorporated molecular-genetic methods, and given the technological challenges

faced by scientists in developing countries, it is unsurprising that the quality of characterizing of *Penicillium* isolates from these crops varies considerably. Accordingly, several names are not cited in the tables, but covered in notes below the tables, with caveats indicated. Table 5 occasionally directs readers to a specific note. Details are provided where a trail of citations ultimately support plausible criteria and literature for assigning specific epithets. Other details note where we were unable to locate literature with definitive criteria. There are instances where specific epithets have been putatively (and invalidly) assigned by citing literature that does not actually provide species descriptions.

Table 1: *Penicillium* subg. *Penicillium* sensu Frisvad & Samson (2004), *P.* ser. *Corymbifera*; with comments on hosts in *Liliaceae* sensu lato

Penicillium albocoremium (Frisvad) Frisvad, Integr. Mod. Taxon. Meth. Penicill. Asperg. Classif: 275 (2000).
- Pathogenic on garlic*, onion, iris, and tulip; less virulent on ornamental onion (*Allium stipitatum*) (Dugan & al. 2017; morpho-cultural, DNA sequence β-tubulin).
- Pathogenic on onion, tulip; non-pathogenic on garlic*, gladiolus (Overy & al. 2005**; morpho-cultural, DNA sequence β-tubulin).
- Additional substrates in Frisvad & Samson (2004).

Penicillium allii Vincent & Pitt, Mycologia 81: 300 (1989).
- Pathogenic on garlic, onion; moderately pathogenic on grass lily and tulip*; non-pathogenic on crocus, daffodil, ornamental onion (*Allium stipitatum*), gladiolus, and iris (Dugan & al. 2014; morpho-cultural, DNA sequence β-tubulin).
- Pathogenic on garlic; non-pathogenic on ornamental onions (*A. aflatunense*, *A. stipitatum*) (Dugan & al. 2011; morpho-cultural, DNA sequence β-tubulin).
- Pathogenic on onion, garlic; non-pathogenic on tulip*, gladiolus (Overy & al. 2005; morpho-cultural, DNA sequence β-tubulin).
- Additional substrates in Frisvad & Samson (2004).

Penicillium hirsutum Dierckx, Ann. Soc. Sci. Bruxelles 25: 89 (1901).
- Pathogenic on crocus, garlic, onion, tulip, moderately pathogenic on gladiolus and iris; non-pathogenic on daffodil, ornamental onion, and grass lily (Dugan & al. 2014; morpho-cultural, DNA sequence β-tubulin).
- Pathogenic on onion, garlic, tulip, gladiolus (Overy & al. 2005; morpho-cultural, DNA sequence β-tubulin).
- Additional substrates in Frisvad & Samson (2004).

Penicillium hordei Stolk, Antonie van Leeuwenhoek 35: 270 (1969).
- Pathogenic on tulip; non-pathogenic on onion, garlic, gladiolus (Overy & al. 2005; morpho-cultural, DNA sequence β-tubulin). However, typically on barley (*Hordeum vulgare* L.) or other cereals, or soil wherein such are cultivated (Frisvad & Samson 2004), but also once isolated from seed of *Lupinus albus* L. in Washington state (Alomran & al. 2013).

Penicillium radicicola Overy & Frisvad, Syst. Appl. Microbiol. 26: 633 (2003).
- Pathogenic on garlic*, onion, and iris; non-pathogenic on *A. stipitatum* and tulip* (Dugan & al. 2017; morpho-cultural, DNA sequence β-tubulin).
- Pathogenic on onion, tulip*; non-pathogenic on garlic*, gladiolus (Overy & al. 2005; morpho-cultural, DNA sequence β-tubulin).
- Additional substrates in Frisvad & Samson (2004), e.g., carrot, sometimes without comment on pathogenicity.

Table 1, concluded

Penicillium tulipae Overy & Frisvad, Syst. Appl. Microbiol. 26: 634 (2003).

Pathogenic on garlic*, onion, iris, and tulip, moderately pathogenic on crocus, daffodil, and grass lily; non- pathogenic on ornamental onion and gladiolus* (Dugan & al. 2014; morpho-cultural, DNA sequence β-tubulin).

Pathogenic on onion (cultivar-dependent), tulip, gladiolus*; non-pathogenic on garlic* (Overy & al. 2005; morpho-cultural, DNA sequence β-tubulin).

Additional substrates in Frisvad & Samson (2004): bulbs of lily (*Lilium* sp.) and (without plant part specified) beet (*Beta vulgaris*) and Jerusalem artichoke (*Helianthus tuberosus* L.).

Penicillium venetum (Frisvad) Frisvad,

Integ. Mod. Taxon. Meth. Penicill. Asper. Classif.: 275 (2000).

Pathogenic on garlic, onion (cultivar-dependent), gladiolus, grass lily, iris and tulip; non-pathogenic on crocus and daffodil (Dugan & al. 2014; morpho-cultural, DNA sequence β-tubulin).

Pathogenic on onion, garlic tulip, gladiolus (Overy & al. 2005; morpho-cultural, DNA sequence β-tubulin).

Additional substrates in Frisvad & Samson (2004): bulbs of *Hyacinthus* spp. (pathogenic), horseradish (*Armoracia rusticana* G. Gaertn. & al., pathogenic, see *P. hirsutum*, Table 5), and "licorice root" (*Glycyrrhiza glabra* L.; pathogenicity not specified).

* Indicates differences in results between investigators, possibly reflecting variation in isolates, inoculation, or incubation.

** Overy & al. (2005) challenged bulbs in more than one anatomical location. Results tabulated above regard lesion formation at any location as a positive result.

Table 2. *Penicillium* subg. *Penicillium* sensu Frisvad & Samson (2004) (other than *P.* ser. *Corymbifera*) with comments on hosts in *Liliaceae* sensu lato.

Penicillium aurantiogriseum Dierckx, Ann. Soc. Sci. Bruxelles 25: 88 (1901)

[*P.* ser. *Viridicata* in Frisvad & Samson 2004 = *P.* sec. *Fasciculata* in Visagie & al. 2014]

Substrates in Frisvad & Samson (2004) include onion, garlic* (*Allium* spp., with pathogenicity implied rather than stated). Non-pathogenic on garlic* in Valdez & al. (2009; morpho-cultural via Ramirez 1982 and others).

Penicillium crustosum Thom, The *Penicillia:* 399 (1930) [*P.* ser. *Camemberti*].

Pathogenic on onion; moderately pathogenic on iris; non-pathogenic on *Allium stipitatum* and tulip (Dugan & al. 2017; morpho-cultural, DNA sequence β-tubulin).

Additional substrates in Frisvad & Samson (2004).

Penicillium expansum Link, Mag. Gesell. Naturf. Freunde, Berlin 3: 17 (1809) [*P.* ser. *Expansa*].

Pathogenic on iris, tulip, onion (cultivar-dependent); moderately pathogenic on garlic (Dugan & al. 2017; morpho-cultural, DNA sequence β-tubulin). Symptoms illustrated (Duduk & al. 2017; morpho-cultural, DNA sequence β-tubulin).

Additional substrates in Frisvad & Samson (2004). The species is most well known as inducing rot of apple (*Malus domestica* Borkh.) fruits.

Penicillium polonicum K.W. Zaleski, Bull. Int. Acad. Polon. C1 Sci. Math., Sér. B: 445 (1927)

[*P.* ser. *Viridicata*]

Pathogenic on garlic, onion; non-pathogenic on *Allium stipitatum*, iris*, tulip (Dugan & al. 2017; morpho-cultural, DNA sequence β-tubulin).

Pathogenic on garlic, onion, moderately pathogenic on iris*; non-pathogenic on crocus, daffodil, ornamental onion, grass lily, and tulip (Dugan & al. 2014; morpho-cultural, DNA sequence β-tubulin). Multiple cultivars of onion; symptoms illustrated (Duduk & al. 2017; morpho-cultural, DNA sequence β-tubulin).

Additional substrates in Frisvad & Samson (2004) include *Allium* sp.

* Indicates differences in results between investigations, possibly reflecting variation in isolates, inoculation, or incubation.

TABLE 3. *Penicillium*, other than *P.* subg. *Penicillium* sensu Frisvad & Samson (2004); with comments on hosts in *Liliaceae* sensu lato.

Penicillium brasilianum Bat., Anais Soc. Biol. Pernambuco 15: 160 (1957)
[*P.* sec. *Lanata-Divaricata*, Visagie & al. 2014; but see also Pitt 1980]
Pathogenic on onion (but significantly less aggressive than the pathogenic *Aspergillus awamori* Nakaz. or *Fusarium oxysporum* Schltdl.—presumably *F. oxysporum* f. sp. *cepae*) (Sang & al. 2014; morpho-cultural, β-tubulin DNA sequences).

Penicillium citrinum Thom, Bull. U.S. Depart. Agric., Bureau Anim. Indust. 118: 61 (1910)
[*P.* sec. *Citrina*, Pitt 1980, Visagie & al. 2014]
Pathogenic on *Allium sativum* (Hernández-Anguiano 2006, using Pitt 1988).

Penicillium georgiense S.W. Peterson & B.W. Horn, Mycologia 101: 79 (2009)
[*P.* sec. *Charlesii*, Visagie & al. 2014]
Pathogenic on onion, moderately aggressive (lesions ~4-5mm at 10 days) (Oh & al. 2015: morpho-cultural, β-tubulin DNA sequences).

Penicillium glabrum (Wehmer) Westling, Ark. Bot. 11(1): 131 (1911).
[*P.* sec. *Aspergilloides*, Pitt 1980, Visagie & al. 2014]
Pathogenic on garlic, onion; moderately pathogenic on iris; non-pathogenic on *Allium stipitatum*, tulip (Dugan & al. 2017; morpho-cultural, DNA sequence β-tubulin). Symptoms illustrated (Duduk & al. 2017; morpho-cultural, DNA sequence β-tubulin). Typically confined to outer layers (Varga & al. 2008).

Penicillium paraherquei S. Abe ex G. Sm., Trans. Brit. Mycol. Soc. 46: 335 (1963)
[*P.* sec. *Furcatum*, Pitt, 2000; *P.* sec. *Lanata-Divaricata*, Visagie & al. 2014]
Pathogenic on garlic, onion (cultivar-dependent); non-pathogenic on *A. stipitatum*, iris, tulip (Dugan & al. 2017; morpho-cultural, β-tubulin DNA sequences).

Penicillium purpureogenum Stoll [as "*purpurogenum*"], Beitr. Morph. Biol. Char. *Penicillium:* 32 (1904) [*P.* ser. *Miniolutea*, Pitt 1980; but see Visagie & al. 2014].
≡ *Talaromyces purpureogenus* (Sopp) Samson & al., Stud. Mycol. 70: 177 (2011).
Treated either as an accepted species (Pitt 1980, 2000; Visagie & al. 2014; Farr & Rossman (2018); Species Fungorum 2018) or as a species complex requiring further study (Samson & al. 2011).
Pathogenic on onion, (Vélez-Rodríguez & Rivera-Vargas 2007; identification corroborated by CABI Bioscience Identification Services).

Comments on TABLES 1–3

Penicillium allii-sativi Frisvad & al. (Houbraken & al. 2012; Persoonia 29: 89): although the epithet refers to the substrate, *Allium sativum,* from which the type was isolated, it is not included in the tables because it is NOT a pathogen on garlic (Houbraken & al 2012).

Penicillium frequentans Westling, identified from morpho-cultural criteria, was isolated from tulip bulbs in Poland, and the closely related *P. spinulosum* Thom has been isolated from onion bulbs in Lithuania (Dugan & al. 2014, and sources cited there). *Penicillium frequentans* is regarded as either an independent species (MycoBank 2018, Visagie & al. 2014) or a synonym of *P. glabrum* (Pitt 1980, Farr & Rossman 2018, Species Fungorum 2018).

Penicillium gladioli L. McCulloch & Thom (not included in tables) "may be extinct" ...; pathogenic to *Gladiolus* corms" (Frisvad & Samson 2004). In spite of "may be extinct," one still sees this name assigned to penicillia reported on *Gladiolus* (e.g., Farr & Rossman 2018). See Pitt (1980) and Index Fungorum (2018) for its sometimes ambiguous nomenclatural history.

Penicillium paraherquei and *P. brasilianum* were previously considered synonyms of *P. simplicissimum* (Oudem.) Thom (Pitt 1980), and *P. paraherquei* (not cited in Farr & Rossman 2018) is still so regarded at Species Fungorum (2018). Isolates identified as *P. simplicissimum* based on Pitt (1980) are recorded from onion (cf. the sources and phylogenetic summary in Dugan & al. 2017). *Penicillium paraherquei* and *P. brasilianum* are accepted as independent species by Visagie & al. (2014) but are treated as synonyms in MycoBank (2018).

Penicillium purpureogenum is sometimes assigned the protologue citation La Cellule 33: 235 (1923). The correct protologue is provided in Table 3.

Some names in Sumner & al. (2008) are problematic because that publication does not explain clearly how a specific epithet was applied to agents of blue mold of onion. There are the cases of *P. citrinum* on onion (a species primarily on *Citrus* but see Hernández-Anguiano 2006); *P. cyclopium* on onion (from a 1978 publication in Sumner & al. 2008) is a synonym of *P. aurantiogriseum* in Farr & Rossman (2018) and Pitt (1980, 2000) but independent in MycoBank (2018) and Visagie & al. (2014); *P. aurantiogriseum* is documented on onion and garlic (see Table 2). *Penicillium digitatum* (Pers.) Sacc. is also mostly on citrus, but host-fungus indices in Farr & Rossman (2018) cite *P. digitatum* on *Iris*, in the same broad family as onion. The sole record in Farr & Rossman (2018) of *P. funiculosum* on onion is from a checklist of fungi in Pakistan, and Farr & Rossman (2018) have no records for *P. oxalicum* on onion. In addition, *P. discolor* Frisvad & Samson, a species noted for its presence on cheeses, is recorded from onion in two cases by Frisvad & Samson (2004), but with no indication of pathogenicity.

Table 4. *Penicillium* spp. on *Beta vulgaris*.

Penicillium cellarum C.A. Strausb. & Dugan, Pl. Dis. 101: 1783 (2017).

[*P.* sect. *Fasciculata*] Phylogenetically allied to: *P. aurantiogriseum* with ITS-5.8S, β-tubulin] (Visagie & al. 2014); *P. camemberti* with RPB2.

Pathogenic on sugar beet roots held in long-term storage piles (Strausbaugh & Dugan 2017; morpho-cultural, DNA sequences: β-tubulin, ITS-5.8S, RPB2). *P. cellarum* is recently described, yet to be evaluated on other crops.

Table 4 concluded

Penicillium cyclopium Westling, Ark. Bot. 11(1): 90 (1911).
Pathogenic on sugar beet roots (*Beta vulgaris*) (Bugbee & Nielsen 1978; morpho-cultural in Raper & Thom 1968).

Penicillium expansum
Pathogenic on stored sugar beet roots (*Beta vulgaris*) (Bugbee 1975; Strausbaugh 2018, morpho-cultural and DNA sequences: β-tubulin, ITS-5.8S, RPB2). Bugbee (1975; by implication, using Raper & Thom 1968) applied the name *P. variabile*, sometimes considered a synonym of *P. expansum* as noted above. Farr & Rossman (2018) do not presently list records of *P. expansum* on sugar beet.

Penicillium funiculosum Thom,
Bull. U.S. Dep. Agric., Bur. Anim. Indust. 118: 69 (1910) [*P.* subg. *Biverticillium*].
≡ *Talaromyces funiculosus* (Thom) Samson & al., Stud. Mycol. 70: 176 (2011).
Pathogenic on sugar beet roots (*Beta vulgaris*) (Bugbee & Nielsen 1978: morpho-cultural via Raper & Thom 1968).

Penicillium polonicum
Pathogenic on stored sugar beet roots (*Beta vulgaris*) in Idaho (Strausbaugh 2018; morph-cultural, DNA sequences: β-tubulin, ITS-5.8S, RPB2).

Penicillium tulipae
On *Beta vulgaris* (Overy & Frisvad 2003; morpho-cultural, extrolites, DNA sequence β-tubulin). *Penicillium tulipae* was twice isolated from *B. vulgaris* and given IBT accession numbers; no indication of pathogenicity provided.

Penicillium variabile Sopp, Skr. Vidensk.-Selsk.
Christiania, Math.-Naturvidensk. Kl. 11: 169 (1912) [*P.* subg. *Biverticillium*].
≡ *Talaromyces variabilis* (Sopp) Samson & al., Stud. Mycol. 70: 177 (2011).
Pathogenic on sugar beet (*Beta vulgaris*) (Bugbee 1975, deposited accession ATCC 28703 but without stating identification method; possibly via Raper & Thom 1968, as this was how Bugbee identified *P. cyclopium* and *P. funiculosum* above). *Penicillium variabile* was rare in sugar beet, relative to *P. vulpinum* (Bugbee 1975).

Penicillium vulpinum (Cooke & Massee) Seifert & Samson,
Adv. Penicill. Asper. System.: 144 (1986) ["1985"]
The synonym *Penicillium claviforme* is common in phytopathological literature. In older U.S. literature *P. claviforme* is the most prevalent *Penicillium* rotting sugar beet (Bugbee 1993). "Clavate coremia, usually produced at 25°C on both CYA and MEA, distinguish *Penicillium claviforme* from all other *Penicillium* species" (Pitt 1980). Bugbee (1975) presented a photo of coremia and deposited representative accession (ATCC 28702).
Additional substrates in Frisvad & Samson (2004).

Comments on Table 4:

Bugbee (1975) also cited Morochkovsky (1936, in Russian) describing additional *Penicillium* spp. inducing sugar beet rot: *P. stoloniferum* Thom (regarded as a synonym of *P. brevicompactum* by Farr & Rossman 2018, Pitt 1980, and Species Fungorum 2018), *P. bordzilowskii* Morochk. (later regarded as a synonym of *P. cyclopium* based on Samson & al. 1976), *P. expansum*,

P. duclauxii Delacr., and *P. rubrum* Stoll. We have not read Morochkovsky's publication and do not know how the isolates were identified.

Liebe & al. (2016) listed *Penicillium paneum* Frisvad based on fungal ITS sequences present in stored beets. The ITS region alone is considered insufficient for species assignment in *Penicillium*, and definitive phylogenetic analyses use alternative or supplemental gene regions (e.g., Samson & al. 2004; Visagie & al. 2014). Although beets were sorted based on their degree of deterioration, Liebe & al. (2016) did not describe inoculations (i.e., Koch's postulates) and thus did not provide a direct measure of pathogenicity.

Table 5: *Penicillium* spp. on edible roots and tubers.

Penicillium albocoremium

On *Zingiber officinale* Roscoe, ginger (Frisvad & Samson 2004; morpho-cultural, DNA sequence β-tubulin). Pathogenicity is implied rather than stated.

Penicillium brevicompactum Dierckx, Ann. Soc. Sci. Bruxelles 25: 88 (1901), [*P.* ser. *Olsonii*].

Pathogenic on *Zingiber officinale*, ginger (Overy & Frisvad 2005; Varga & al. 2008, literature review, citing sources; morpho-cultural, metabolite profiles).

Penicillium crustosum

On *Dioscorea alata* L., purple yam (Pitt 1980, citing an IMI accession), with comment on pathogenicity. See comment on Snowdon (1992) below.

Penicillium expansum

On *Dioscorea* spp., yam (Frisvad & Samson 2004). On *Ipomoea* spp., see comment on Holmes & Clark (2013) below.

Penicillium hirsutum

On horseradish roots (*Armoracia rusticana;* Frisvad & Samson 2004) but without indicating pathogenicity; morpho-cultural, DNA sequence β-tubulin). "*P. hirsutum* is a major cause of loss of stored horseradish" (Beuchat 1987). However, Beuchat (1987) may have been referring to what was subsequently described as *P. hirsutum* var. *venetum* Frisvad (Frisvad & Filtenborg 1990), the basionym of *P. venetum*, Table 1.

Penicillium oxalicum Currie & Thom, J. Biolog. Chem. 22: 289 (1915)

[*P.* sec. *Lanata-Divaricata*, Visagei & al. 2014].

On sweet potato (*Ipomoea batatas* (L.) Lam.; Paul & al. 2018, with illustrations of symptoms; methods: morpho-cultural, DNA sequences: β-tubulin, ITS). See comment on Snowdon (1992) in notes.

On *Dioscorea* spp., see comment on Snowdon (1992) below. Pathogenic on cush-cush yam (*Dioscorea trifida* L.f.; Ricci & al. 1979; morpho-cultural, implying use of Raper & Thom 1949 for identification).

Pathogenic on *Dioscorea alata, D. cayenensis* Lam., *D. dumetorum* (Kunth) Pax, and *D. rotundata* Poir. (Adeniji 1970: "Identifications were confirmed by the Commonwealth Mycological Inst., Kew, England.")

Penicillium polonicum

On Chinese yam [*Dioscorea batatas* Decne. (= *D. polystachya* Turcz.)], Kim & al. (2008; morpho-cultural, DNA sequence β-tubulin). No pathogenicity tests were performed.

Table 5 concluded

Penicillium purpureogenum

FRR 1977 "from cassava [*Manihot esculenta* Crantz] ... Representative of species" (Pitt 1980); no indication of pathogenicity.

Penicillium sclerotigenum T. Yamam., Sci. Rep. Hyogo Univ. Agric., Ser. 2, Agr. Biol. 2: 69 (1955) [*P.* ser. *Expansa*].

On yam (*Dioscorea* spp.), tubers and products (Frisvad & Samson 2004).

On *Dioscorea batatas* (Kim & al. 2008), but without pathogenicity tests; methods: morpho-cultural, DNA sequence β-tubulin). Pitt's (1980) different classification placed *P. sclerotigenum* in *P.* subg. *Furcatum* but did describe the species as rotting *Dioscorea* spp. See comment on Snowdon (1992) in notes.

Comments on Table 5:

Holmes & Clark (2013) provided species names for penicillia causing blue mold on sweet potatoes but did not specify the identification methods. "*Penicillium* spp. identified from ...isolates collected in North Carolina packing houses: *P. expansum* [the most common], *P. bilaiae* Chalab., *P. variabile, P. rugulosum* Thom, *P. solitum* Westling [variously treated as a synonym of *P. aurantiogriseum* (Pitt 1980), an independent species (Pitt 2000, Visagie & al. 2014), or as a separate species with *P. crustosum* a junior synonym (Species Fungorum 2018)], and *P. viridicatum* Westling [treated as a distinct species by Pitt (1980, 2000) and Visagie & al. (2014), but as a junior synonym of *P. aurantiogriseum* by Species Fungorum (2018)] (Holmes & Clark 2013, authors of species names added). The reference on *Penicillium* in Holmes & Clark (2013) is Harter & al. (1918), which states, "The species of *Penicillium* which we most frequently isolated ... was given to Dr. Charles Thom ... it belongs to the *expansum* group"). Holmes & Clark (2013) contained a good photo of *P. expansum* by Holmes, clearly showing synnemata typical of the species in vivo. Holmes, on the faculty at North Carolina State University (Department of Plant Pathology), was co-author on Edmunds & al. (2008) produced by the North Carolina State University Extension and co-author with John Pitt (Holmes & al. 1994); Holmes identified the isolates based on Pitt (1980, 2000) (Gerald Holmes, pers. comm.). Holmes & Clark (2013) did not provide explicit statements regarding pathogenicity of individual species.

Snowdon (1992) listed the following species on yams: *P. crustosum* ("very common on yams imported into the UK from Nigeria," but without supplying a citation); *P. cyclopium* (referring only to a previous section on that fungus, not on yam); *P. gladioli* ("has been found on importations to the USA from Cuba and Puerto Rico," but without a citation); *P. oxalicum* (citing Adeniji 1970—see Table 5—and Ricci & al. (1978), who provided no identification methods did reference Ricci & al. 1979, see Table 5);

P. sclerotigenum (citing Yamamoto & al. 1955 as well as Moura 1980, who in turn cited Moura & al. 1976). Snowdon (1992) also cited Plumbley & al. (1985), which does not contain information on identification methods, but refers to Plumbley & al. (1984, similarly devoid of such methods), who did cite earlier reports, including Ogundana & al. (1970), which stated "... microorganisms were isolated and identified" but which otherwise provided no methods or references by which *Penicillium* isolates could conceivably be identified to species. Nonetheless, growth rate, conidial size, and teleomorph absence detailed in Moura & al. (1976) convincingly led to *P. sclerotigenum* in the synoptic key to sclerotigenic species in Pitt (1980).

Snowdon (1992) also mentions *Penicillium* sp. on "cocoyams (taro [*Colocasia esculenta* (L.) Schott] and tannias [*Xanthosoma sagittifolium* (L.) Schott]);" and *Penicillium* spp. on sweet potatoes without providing specific epithets for penicillia on any of these crops. Farr & Rossman (2018) record the following on *Ipomoea*: *Penicillium chrysogenum* Thom, *P. citrinum, P. crustosum, P. decumbens* Thom, *P. expansum, P. funiculosum, P. glabrum, P. islandicum* Sopp, *P. italicum* Wehmer, *P. oxalicum, P. pinophilum* Hedgc., *P. purpureogenum,* and *P. simplicissimum,* but in each instance cite only a regional checklist. It is difficult to confirm reports of *Penicillium expansum* on yam (*Dioscorea*), and they are not cited in Farr & Rossman (2018).

For cassava (*Manihot* spp.), Farr & Rossman (2018) cite a checklist of fungi in Papua New Guinea and one research article from India listing three *Penicillium* species on *Manihot* spp. However, the *Penicillium* species listed in India were assessed as non-pathogenic in artificial inoculations, and no identification methods were provided nor can be inferred from the references listed.

Discussion

DNA sequence analyses, especially of β-tubulin but also of RPB2 and even ITS (for subgeneric groups), along with advances in understanding phylogenetic significance of metabolite production, has substantially reinforced morpho-cultural methods for identifying *Penicillium* isolates to species. Subgeneric assignment changes include transferal of *P. vulpinum* (Table 4) from *P.* subg. *Biverticillium* to *P.* subg. *Penicillium* (Pitt 2000), but the distinctive coremia in *P. vulpinum* consistently enabled assignment of that specific epithet to isolates regardless of higher level classification. Note that although Houbraken & Samson (2011) assigned *Penicillium* species to only two subgenera—*P.* subg. *Aspergilloides* and *P.* subg. *Penicillium*—

for heuristic reasons we use prior subgeneric assignments in Tables 1–3, given that most identification literature uses these prior classifications. Pitt (2000) also noted that he (Pitt 1980) "suggested that only 70–80% of isolates even from common sources are readily identifiable. The remainder can be identified, but their identification must increasingly rely on the skill and experience of the taxonomist and/or newer techniques such as metabolite profiles or molecular data." This comment explains the difference between the large strides in identifying agents of blue mold of edible and ornamental bulbs (primarily grown in economically and scientifically advanced temperate regions) and the somewhat lagging identification of agents of blue mold on tropical and subtropical roots and tubers (primarily grown in tropical regions with developing economies).

There are repeated instances in older phytopathological literature (from both advanced and developing economies) of cavalier treatment of identification. Much older and even some newer literature substituted repetitious "citation" recycling instead of explicitly specifying the monograph or species description on which the name ultimately rested. Through diligence, some confusions can be resolved by tracing a citation trail back to an early monograph (e.g., Raper & Thom 1949), but ultimately modern morpho-cultural observations and DNA sequence analyses must be provided.

Several online publications from developing regions cite various editions of H.L. Barnett & B.B. Hunter (Illustrated genera of imperfect fungi), T. Watanabe (Pictorial atlas of seed and soil fungi), and/or F.M. Dugan (The identification of fungi) for determining species names for *Penicillium* isolates derived from roots, tubers, or bulbs. Such manuals are useful for recognizing fungal families and genera, but as they are entirely inappropriate for applying specific epithets to *Penicillium* isolates, we omit literature citing those manuals for assigning species names. We expect inappropriate citations will diminish as comprehensive monographs on *Penicillium*—as well as equipment and skills needed for DNA sequence analyses—become more widely available. We accordingly anticipate increased knowledge of agents of *Penicillium* blue mold of crops such as cassava, sweetpotato, ginger, taro, and tannia.

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Sulzbacheromyces yunnanensis, a new record for Thailand

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Abstract—Specimens of a clavarioid basidiolichen collected in Thailand were identified as *Sulzbacheromyces yunnanensis*, based on morphology and similarities of ITS genes. A full description and illustration are provided. This is the first record of *S. yunnanensis* from Thailand

Key words—*Basidiomycota*, *Lepidostromataceae*, *Lepidostromatales*, Southeast Asia, taxonomy

Introduction

Sulzbacheromyces (*Lepidostromataceae*, *Lepidostromatales*) was described by Hodkinson & al. (2014) with *S. caatingae* (Sulzbacher & Lücking) B.P. Hodk. & Lücking as the type species. This genus is distributed in Africa, Asia and the neotropics. Eight species of *Sulzbacheromyces* have been described: *S. bicolor* D. Liu & al., *S. caatingae*, *S. chocoensis* Coca & al., *S. fossicola* (Corner) D. Liu & Li S. Wang, *S. miomboensis* De Kesel & Ertz, *S. sinensis*

(R.H. Petersen & M. Zang) D. Liu & Li S. Wang, *S. tutunendo* Coca & al., and *S. yunnanensis*. *Sulzbacheromyces* is characterized by clavarioid basidiomata combined with a lichenized crustose basal thallus with a chlorococcoid photobiont (Hodkinson & al. 2014, Sulzbacher & al. 2016, Liu & al. 2017, Coca & al. 2018).

Currently, only one *Sulzbacheromyces* species, *S. fossicola* has been reported from Thailand (Liu & al. 2017). During a survey of macrofungi collected in northeastern Thailand, we found specimens that corresponded to the description of *S. yunnanensis*, a species previously reported from China (Liu & al. 2017). Here we describe and illustrate the morphological characteristics of the Thai material and provide evidence of ITS gene sequence matches in GenBank.

Materials & methods

Morphology

Basidiomata were collected from the forest, Sisaket Province, Thailand, and kept in plastic collection boxes until transported back to the laboratory. Macroscopic descriptions of specimens were based on examination of fresh basidiomata. Ecological observations were recorded and photographs were taken in the field. Color names and codes follow Kornerup & Wanscher (1978). The specimens were dried at 40–45 °C in an electric food dryer. The micromorphological data were derived from dried specimens mounted in 95% ethanol and rehydrated in distilled water, 3% KOH, or Melzer's reagent. Dried specimens were deposited in the herbarium of Research Laboratory for Excellence in Sustainable Development of Biological Resources, Faculty of Science, Chiang Mai University, Thailand (SDBR-CMU).

DNA isolation, amplification, analyses

Genomic DNA was extracted from fresh material using a Favorgen DNA Extraction Mini Kit following the manufacturer's instructions. The internal transcribed spacer (ITS) region of ribosomal DNA (rDNA) was amplified by polymerase chain reaction (PCR) using ITS4 and ITS5 primers under the following thermal conditions: 94 °C for 2 min; 35 cycles of 95 °C for 30 s, 52 °C for 30 s, and 72 °C for 1 min; and 72 °C for 10 min. Negative controls lacking fungal DNA were run for checking any contamination of reagents. PCR products were checked on 1% agarose gels stained with ethidium bromide under UV light and purified using a Macherey-Nagel NucleoSpin Gel and PCR Clean-up Kit following the manufacturer's protocol. The purified PCR products were directly sequenced. Sanger sequencing was performed by 1ST Base Company (Kembangan, Malaysia) using the PCR primers cited above. Sequences were used to query GenBank database via BLAST (http://blast.ddbj.nig.ac.jp/top-e.html).

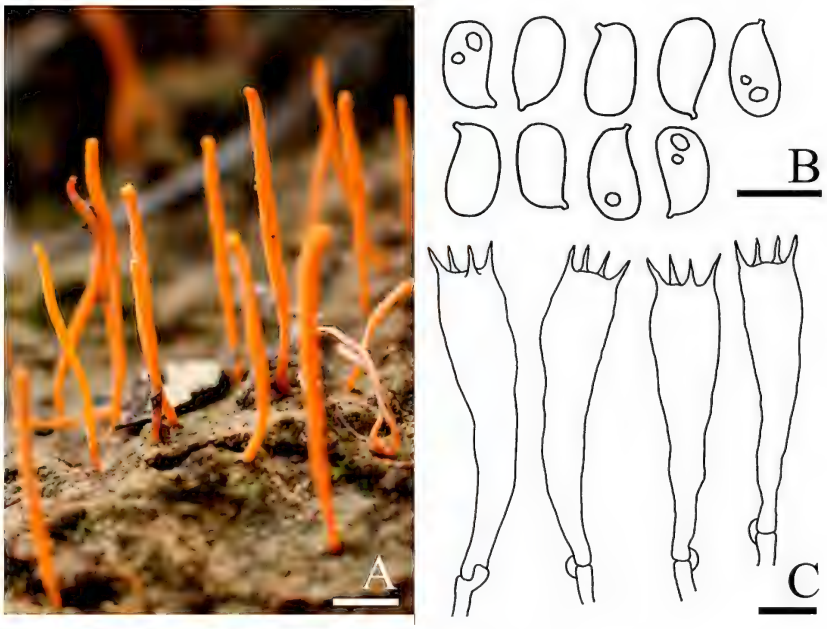

Fig. 1. *Sulzbacheromyces yunnanensis* (SDBR-CMU-NK0329).
A: basidiomata; B: basidiospores; C: basidia. Scale bars: A = 10 mm; B, C = 10 µm.

Sequence analysis

The ITS sequences of our Thai specimens were deposited in GenBank database as MK085985 and MK086016. Our ITS sequences were 100% similar to the *S. yunnanensis* KUN 14-44123 holotype sequence NR159026.

Taxonomy

Sulzbacheromyces yunnanensis D. Lui, Li S. Wang & Goffinet,
Mycologia 109: 742 (2017). Fig. 1

Thallus crustose, covering an area of 0.5–50 mm diam., distinct and dark green when growing in shade or depressions, but yellow green and indistinguishable from soil when growing on exposed ground; forming a thin layer on the substrate, containing clusters of single-celled chlorococcoid algae, without prothallus. Photobiont chlorococcoid, 4–10 µm diam., globose to subglobose, smooth, contiguous, surrounded by a single layer of hyaline hyphae. Basidioma solid, clavarioid or cylindrical, fusiform or heliciform, simple (rarely once branched), with two conspicuous wide longitudinal

depressions or grooves, never circled by transverse cracks at maturity, apex obtuse to narrowly obtuse to truncate, 25–50 × 0.5–2.5 mm, with hymenium tissue covering the upper part; surface pruinose, without tomentum or mycelial patch at the base, orange-yellow (4A7) or light orange (6A4) when exposed to rain and direct sunshine, orange (6A6) in shaded habitat, base dark ochraceous, turning ochraceous overall upon drying. Trama hyphae 2–7 µm diam., parallel aligned, clamped, slightly thick-walled, densely agglutinated, with a bulbous apex. Hymenium 70–80 µm thick.

Basidiospores 8.5–12 × 3.5–5.8 µm (n = 50), Q = 2.0–2.4, ellipsoid to slightly reniform, thin-walled, hyaline, smooth, sometimes guttulate. Basidia 50–75 × 5–6.5 µm, oblong when young, subclavate to clavate when mature, thin-walled, hyaline, 4-spored, with basal clamp connections and sterigmata ≤5 µm long.

Specimens examined — **THAILAND, Sisaket Province, Khun Han District**, 14°52′20″N 104°38′01″E, elevation 208 m, on soil, 2 June 2018, Suwannarach N. & Kumla J. (SDBR-CMU-NK0329; GenBank MK085985); 3 June 2018, Suwannarach N. (SDBR-CMU-NK0342, GenBank MK086016).

Discussion

The clavarioid basidiomata, lichenized crustose basal thallus, and chlorococcoid photobiont support placement of our collections in *Sulzbacheromyces* (Hodkinson & al. 2014). The two specimens collected in northeastern Thailand were morphologically identified as *S. yunnanensis* based on the descriptions and keys in Liu & al. (2017). The orange-yellow to orange basidiomata of *S. yunnanensis* are similar to those of *S. caatingae*, *S. chocoensis*, *S. miomboensis*, *S. sinensis*, and *S. tutunendo*. However, the longer basidia of *S. yunnanensis* (50–75 µm) clearly distinguish this species from *S. caatingae* (23–45 µm), *S. chocoensis* (25–40 µm), *S. miomboensis* (21.1–30.3 µm), *S. sinensis* (15–50 µm), and *S. tutunendo* (25–40 µm) (Sulzbacher & al. 2016, Liu & al. 2017, Coca & al. 2018). The basidiospores of *S. caatingae* (5–8.5 µm), *S. chocoensis* (4 µm), and *S. tutunendo* (4 µm) (Sulzbacher & al. 2016, Coca & al. 2018) are clearly shorter than those of *S. yunnanensis* (8.5–12 µm). The ITS sequence matches in GenBank confirmed our two Thai specimens as *S. yunnanensis*, supporting the morphological identification (Coca & al. 2018).

Including our new record, four species of *Sulzbacheromyces* have been reported in Asia (Liu & al. 2017): *S. bicolor* in China; *S. fossicola* in China, India, Singapore, and Thailand; *S. sinensis* in China and Japan; and *S. yunnanensis* in China and Thailand. Of the four other *Sulzbacheromyces* species, three (*S. caatingae*, *S. chocoensis*, *S. tutunendo*) are known from the neotropics

(Brazil and Colombia; Sulzbacher & al. 2016, Coca & al. 2018), while *S. miomboensis* is known only from Africa (Democratic Republic of Congo; Liu & al. 2017).

The present study combining morphological characteristics and sequence data supports the identification of *S. yunnanensis* and a new record for Thailand.

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Mycobiota (Funga) new to the Mycotaxon website

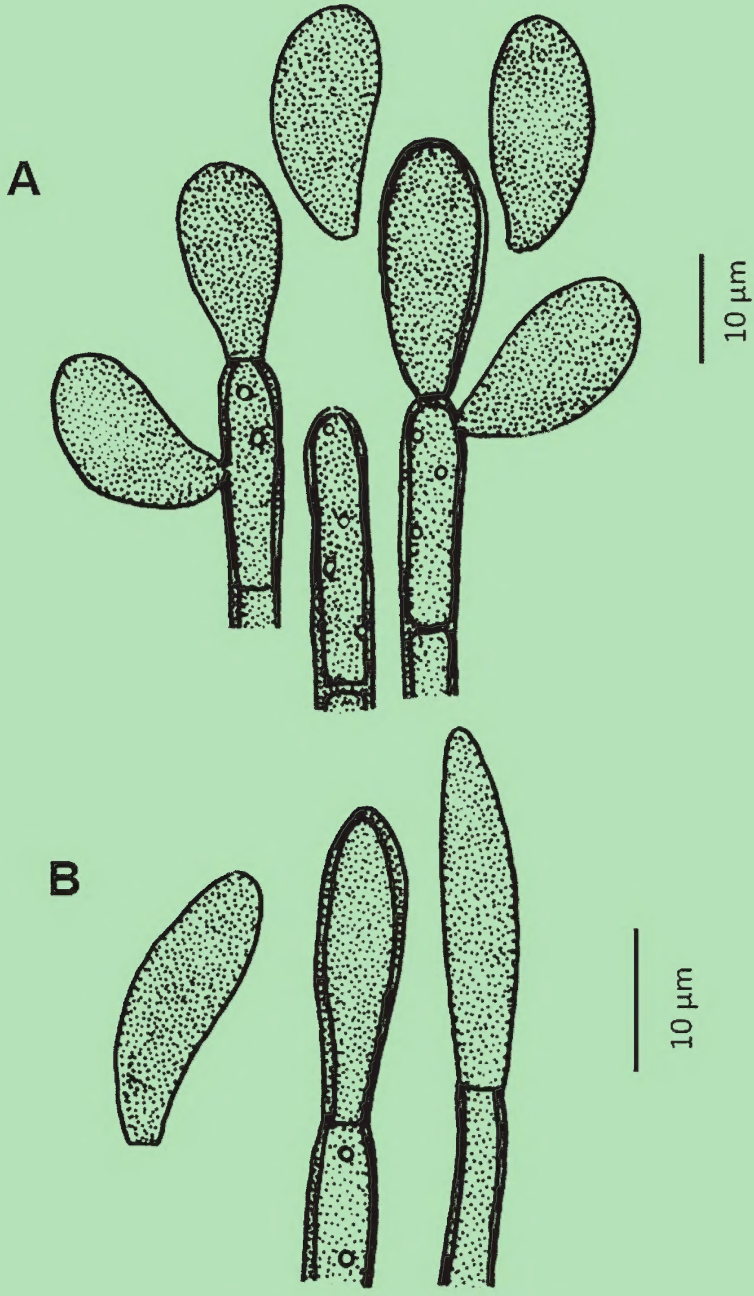
Abstract—In February, Mycotaxon added the first annotated species distribution list from the Indian Subcontinent (India) to our 'web-list' page: 'A checklist of the non-gilled fleshy fungi (*Basidiomycota*) of Kerala State, India' by T.K. Arun Kumar, Anjitha Thomas, Krishnapriya Kuniyil, Salna Nanu, and Vinjusha Nellipunath. This brought to 131 the number of free access Fungae now available on our website: http://www.mycotaxon.com/mycobiota/index.html

ASIA

India

T.K. Arun Kumar, Anjitha Thomas, Krishnapriya Kuniyil, Salna Nanu, Vinjusha Nellipunath. A checklist of the non-gilled fleshy fungi (*Basidiomycota*) of Kerala State, India. 8 p.

Abstract—Kerala is a geographically unique state in India with more than half of its area encompassed within the Western Ghats hill ranges. The peculiar physiographic, edaphic and climatic conditions that prevail in Kerala contribute to a rich biological diversity. A literature-based checklist of the non-gilled, fleshy basidiomycetes of Kerala is presented herein. The list includes 81 species (*Agaricomycetes, Dacrymycetes,* and *Tremellomycetes*) that have been documented and published from the region thus far, excluding polypores. The listed species belong to 39 genera in 18 families placed in 11 orders. *Boletus* and *Lycoperdon* are the genera represented by the most species.



Anisospadicoides macrocontinua **gen. & sp. nov.**
(Qiao & al.— Fig. 1, p. 163)
Rafael F. Castañeda-Ruíz, *artist*